Design of Mobile Technologies for Traveling with Public Transport

A Battle Against Information Overload

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A Battle Against Information Overload

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Abstract

The thesis is a part of the project *Mobile Applikasjoner Underveis*. The project aims at finding out which mobile applications can make the public transport travel experiences more attractive. The focus of this thesis is solving two problems at the same time: Design mobile application to provide users the updated information about public transport, and design mobile application to avoid *information overload*.

To conduct the investigation, I first reviewed the theoretical work regarding the problem field. Then I designed a mobile application *Trafficker* as my proposed solution to the research problem, based on the theories, technologies and design concepts that I reviewed. Later on I conducted empirical fieldwork, using qualitative research strategy, to investigate users' routines and needs regarding using public transport and mobile technologies as well as test the theories, technologies and design concepts that were introduced earlier. The data collection methods include interview, usability testing and ethnography.

The findings showed that, giving users the choice of controlling the way they are receiving information and giving users the exact information they want, are the two key points to avoid *information overload* when designing mobile applications. *Presence awareness* and *context-aware computing* can help to realise these purposes. Other than that, privacy concern, stability, simplicity, readability and universal design are the important considerations that need to be taken into account when designing public transport mobile application.

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Chapter 1. Introduction

Sun Yat-sen, in his philosophical work "Three Principles of the People"[1], introduced the expression of "clothing, food, shelter and transportation" (in Chinese: Yi Shi Zhu Xing 衣食住行) as the basic necessities of life. This expression later on became Chinese mentality and a common expression for describing the four basic needs of people in everyday life. This notion apparently is not only Chinese characteristic but can also be applied world widely.

Needless to say, transportation is an important part of most people's everyday lives. Especially for people living in the urban areas, public transport very often plays an essential role in their daily activities. In the mean time, the mobile technology usage in people's everyday lives becomes more and more visible nowadays. Many different types of public transport mobile applications are available in the application shop for people to download. They can serve different purposes. For example, there are applications for planning trips, applications to be used by on the way, and applications for sharing information among travellers. The overall function of these applications is to help people have better public transport experiences.

However, travellers' needs are not all satisfied with these mobile applications. Moreover, using mobile applications may bring some other

1 "Three Principles of the People" is a political philosophy developed by Sun Yat-sen as part of a philosophy to make China a free, prosperous, and powerful nation. The three principles are often translated into and summarized as nationalism, democracy, and the livelihood of the people. Source: https://en.wikipedia.org/wiki/Three_Principles_of_the_People

troubles to the travellers that they may not have expected.

This thesis will look into travellers' usage of public transport and mobile technologies, and investigate the design implications for bringing travellers better travel experiences with mobile technologies.

1.1 Motivation and background

According to the survey study in report "Mobile applications on the way – What do the travellers want?" (Julsrud et al., 2014), one of the challenges and opportunities for designing mobile application is to meet travellers' needs of getting updated public transport information both before and during the travel. To have a feeling for this challenge, I will first give a real-world example:

Due to some signal problems, the airport trains stopped on a normal winter wednesday morning March 11, 2015 in Oslo, Norway. People panicked. Not to mention the inconvenience the delay brings people, it may also cost some people missing their flights. For those who have already came to the train station and found out there was no train, it is often too late to change the plan to take other types of transportation. This was apparently a big problem. However, according to the spokesman Harry Korslund from the railway company, "The problem should be solved by itself for those people who check if the train goes as usual before they travel"[2] ("Feil Stoppet Flytoget - Klar Tale," 2015). It seems like the problem should be easily solved if only every traveller has a good habit to check if the train goes before they travel.

People nowadays have easy access to all sorts of information through various of computing devices. For example, in Oslo, Norway, the updated public transport information is available on the internet[3]. If so, why is it such a challenge for travellers to get updated information?

Theoretically, it works. In reality, let's see.

I will use the above news as an example. I will imagine a few types of people in that situation. You may relate yourself to one of them.

2 The original sentence was: "Det kan lønne seg for de som skal reise å sjekke om togene går i tide."

3 There are various sources for the information. e.g. Ruter, Google map.

You can be John, who's super cautious and sometimes over-worried. John checks the public transport information on the website every time before he travel. He wants to make sure that if there's sudden change with his travel route, he would be able to know it as soon as possible and make alternative plans. Most time of the year, he finds no change information with his routes. Ok, it may be a bit waste of time in most days. But this waste will all be worthy when comes to a day like this: He is going to catch a flight in the morning. He as usual, turn on the laptop, wait for the laptop to start up, open the browser, open the link for the website, wait for the webpage to load, then type in his travel route to the airport: The airport train is delayed! He quickly decided to drive to the airport instead. Crisis solved. John is very happy.

Or, you can be Mary, who is a mobile technology enthusiastic and has many different mobile applications on her smart phone. She also has a mobile application for public transport. The application push information to her when there's change to her “favourite” travel routes (which can be set up by herself). Mary is quite sure she is exempt from missing any information since she is always alert with all the informations coming from the phone. This morning is a bit chaotic. She's going to catch a flight soon. During her rushing preparing-for-leaving time, she heard her phone constantly making alert sounds. She went to her phone several times to check what the informations were about. Turned out the mailbox application says she got some new emails; the weather application says it's going to be a cold day so dress accordingly; the TV show applications says her favourite TV show is back from the winter break and will be on TV tonight; the facebook application says she got a new message; her whatsapp application says she got a new message there too...She got very impatient and annoyed eventually. She couldn't concentrate in packing her stuff and keep a clear mind. Later the phone rang again and it was the information about the airport train delay. She felt so lucky that she got the information early enough therefore she was able to change the travel plan and take the airport bus instead. She made to the bus and everything was fine until the bus was almost at the airport. Mary suddenly remembered to check her wallet, OOPS, she forgot her passport! Her fortunate morning turned into a disaster. After all she had so many things to deal with, including millions of informations, in a very busy morning. How can you expect her to remember everything?

You can also be Steve, who is not as much information alert as Mary. He usually only checks his phone when he feels like to. In the morning, he usually keeps the phone sound off. There're a lot of things to do in the morning and he doesn't want to be distracted. He has the same public transport mobile application as Mary. He's also going to catch a flight this morning. He did everything in pace as he usually does before leaving. Right before leaving the door, he picked up his phone and had a peek. He didn't notice the tiny icon at the upper corner of the screen which was among several other icons. If he noticed and swipe on the tiny icon, he would have seen one message: “The airport trains are delayed. Better try another way to get to the airport.” He only had the time to have a glance at the phone. How can you expect him to notice that tiny little icon? Sorry for him.

See the two problems here in reality? First, people may not get the updated information all the time even with the access to information technologies; second, people may feel overwhelmed if the amount of information they receive is too much.

The interaction between human and computing devices are normally two-directions: Human actively obtain information from computing device, or computing device push information to human. In this case, it is apparently not reasonable to ask every traveller to check their computing devices for updated information every time before travel. It usually takes time and a lot of steps. The alternative would be computing devices pushing information to travellers. However, it brings another problem, in the current information age, many people are already getting a lot of informations from various of sources, people need to deal with a lot of information which sometimes is over their processing limit. As a result, they feel disturbed and annoyed by the information and end up not making the best decisions. There is a term for this phenomenon that just happened: *information overload*.

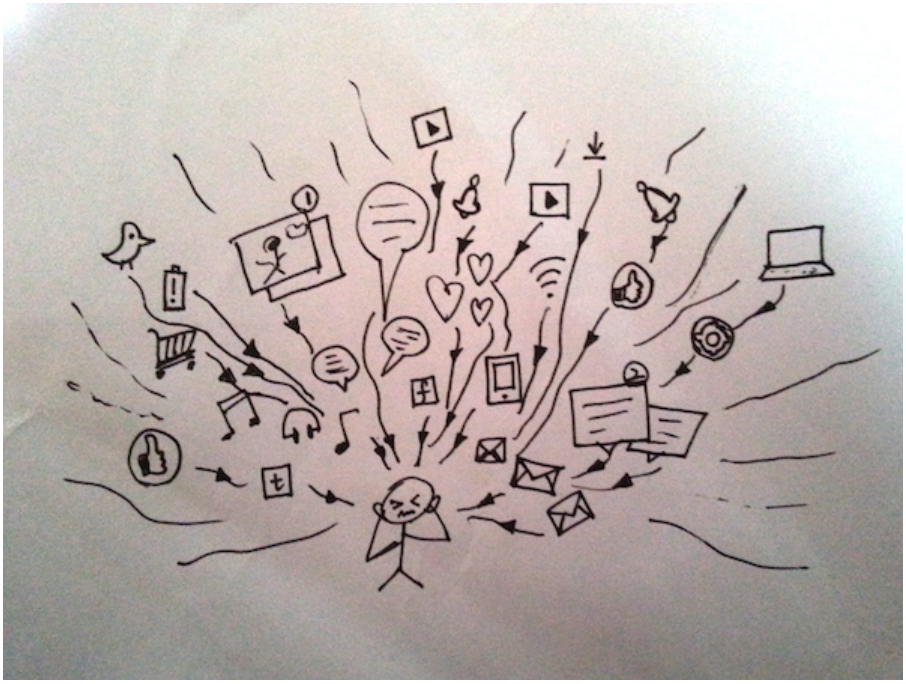

Figure 1.1: An illustration of information overload (own illustration)

Information overload describes the phenomenon when people are trying to deal with more information than they are able to process, they end up with not making the best decisions. It is an increasing problem in information society, as people nowadays are having more access to more informations, however human brain's ability of processing information has limitation (Jackson and Farzaneh, 2012). Hemp (2009) describes it as: while enjoying the convenience of receiving informations, people are also suffering from the flood of distracting and unmanageable information coming in the form of instant messages, social network updates, emails, etc.

Information overload can be harmful in many ways: People can generate the stress of wanting to deal with every single information they receive but simply are not able to process all of them; people are not able to make the best decision regarding the information due to the stress; it can lead to a decrease of people's intelligence (Hemp, 2009); it can be a source of interruption to people's daily lives; it can be a source of interruption in the work environment (Speier et al., 1999).

Therefore, it is wise to consider the effect of *information overload* when designing a mobile application.

This thesis is part of the research project *Mobile Applikasjoner Underveis*[4]. The purpose of the project is to investigate travellers's routines and needs in terms of using mobile technologies and public transport, in order to find out which mobile applications can help to make the public transport travel experience more attractive. Based on the survey result mentioned earlier, this thesis aims at investigating the design challenge of meeting travellers' needs of getting updated public transport information both before and during the travel, as well as catering for other needs of the travellers when using public transport. Among all the challenges, I will concentrate on *information overload* as the primary challenge. The reason for that is, *information overload* is an increasing problem in the mobile technology facilitated world, however the phenomenon hasn't been paid too much attention by the researchers regarding the design of mobile application.

As a master's student in the Interaction Design discipline, I'm intrigued by the design function of making changes in people's everyday lives. I'm interested in *Human–Computer Interaction (HCI)*, *User Experience (UX)*, *User-Centered Design (UCD)* and related areas. How can human-being and the modern technology better communicate with each other is always a question I ask myself and triggers me to explore more in the design world.

1.2 Research questions

This thesis focuses on two main problems regarding designing mobile applications: how to design a mobile application of public transport to meet travellers' needs, including getting updated information; how to avoid *information overload* while providing the information.

Therefore, step by step, I am going to investigate several questions in this study:

1. **The exploration of the phenomenon: information overload**
   The exploration will be conducted through a combination of theoretical study and fieldwork study. I will first study the problem of *information overload* based on others' work. Later I will combine the data from the fieldwork and compare with other author's work. By doing this, I hope to reach a deeper understanding about

4 Mobile Applikasjoner Underveis: see https://www.toi.no/publikasjoner/mobile-applikasjoner-underveis-hva-onsker-de-reisende-article32965-8.html

information overload. The problem is divided into three sub-questions:

a). What is *information overload*?

b). How has the concept developed in recent years?

c). What are the influential factors to the phenomenon of *information overload*?

2. How to design the mobile application to avoid increasing information overload for the users?

To answer this question, I will first review several theories or technologies that are suggested by other authors as possible solutions for *information overload*. Then I will showcase a design of mobile application *Trafficker* that is suggested by myself as one possible solution. Later I will conduct fieldwork based on these theories, technologies and the design concept of *Trafficker*. The purpose of the fieldwork is to find out how these suggested solutions work in users' cases, as well as looking for other possible solutions.

3. How to design the mobile application to cater for travellers' needs in terms of using public transport?

Apart from travellers' needs of getting the updated information, this study also investigate other needs of travellers regarding using mobile technologies. In order to answer this question, I will first review several important design concepts in *Human-Computer Interaction (HCI)* research area. Then I will conduct fieldwork that aims at investigating the routines and needs of the users in terms of using mobile technologies and public transport, as well as testing the design concept of *Trafficker*. In the end, I will do analysis on the data from fieldwork, in order to look for possible answers to the question.

1.3 Overview of the theoretical field

In order to investigate the research questions, solid theoretical knowledge regarding the problem area is needed. Therefore, I start with reviewing the theory field that is in concern of the research questions.

First, I will introduce the research field of this study: *Human-Computer Interaction (HCI)*. Then I will look into the phenomenon of *information overload*. There are several aspects of the phenomenon that I'm concerned

about: the definition of *information overload*; how is the phenomenon of *information overload* like in the current information age; the factors that influence the phenomenon. After that, I will introduce the theories or technologies that mentioned by other authors as the possible solutions for the problem of *information overload*. These theories or technologies are as follows:

- *Presence awareness*. Presence is users' level of availability for dealing with information. *Presence awareness* is the knowledge of the users' presence, i.e., knowing whether the users are available to deal with information. *Presence awareness* helps the users to organise their availability in terms of when to receive information.
- *Context-aware computing*, refers to the idea that mobile devices or mobile applications provide different services when the users are in different contexts.
- *Ubiquitous computing*, refers to the phenomenon that people can freely enjoy the computing technology on any of the devices (smart phone, tablet, laptop, etc.) at any of the locations (home, office, on the road, beach, mountain, etc.).
- *Wearable technology*, refers to the technology that enables the integration of computer or electronic technologies and the items people can wear on their body in daily life, such as clothing or accessories.

In the end, I will look into several important design considerations regarding mobile application design. The considerations include: mobile technology, *design thinking*, *user experience*, *usability*, *universal design*, and the research result from the review of mobile application for public transport (Julsrud et al., 2014).

1.4 Research design

This research is an empirical research adopting qualitative research method. The data is collected using multi-methodology. The data collecting methods include interview, usability test, and ethnography.

Inspired by Android Wear's concept *glanceability* (“Android Wear,” 2015), and based on the review of theories and technologies, I designed a mobile application *Trafficker* to send travellers updated information about public transport. The purpose of designing this mobile application is to further test the theories, technologies, and the *glanceability* design concept in the user

cases. The concept is tested by usability tests.

1.5 Thesis outline

Chapter 1 – Introduction
This chapter provides my personal and professional motivation for writing the thesis.

Chapter 2 – Case
This chapter is an introduction to the research background of the thesis: project *Mobile Applikasjoner Underveis*.

Chapter 3 – Theoretical Considerations
This chapter provides the theoretical background of the thesis.

Chapter 4 - A Design of Mobile Application
This chapter presents the design process of a mobile application: *Trafficker*.

Chapter 5 – Methods
This chapter presents the methodology choices of the thesis.

Chapter 6 – Findings
This chapter presents the data findings from the fieldwork.

Chapter 7 – Discussion
This chapter discusses the data findings in light of the theories, technologies, and design concepts that were introduced in chapter 3 and chapter 4.

Chapter 8 – Conclusion
This chapter concludes the thesis and give indications for the future work.

Chapter 2. Case

This thesis is a part of the Project *Mobile Applikasjoner Underveis*. In this chapter, I am going to give a general introduction to the project. and I am going explain my research area within the project.

Mobile Applikasjoner Underveis (Julsrud et al., 2014) is a project that aims at finding out which mobile applications can help to make the public transport travel experience more attractive. The project is a collaboration between the Institute of Transport Economics, Viktoria Institute (Gothenburg), Institute of Informatics (UIO) and NSB. Meanwhile, the project is supported by Transnova, NSB, NPRA, Flytoget and Ruter. The project is a cooperative work between Tom Erik Julsrud, Jon Martin Denstadli, Jo Herstad, Anders Hjalmarsson, Bent Flyen and Ying Li (me).

While smart phones, tablets and other mobile technology getting more and more popular, it creates more chances to help to make the public transport more attractive and competitive compared to private car. Mobile applications have big potential of providing convenience and fun during people's travel. The researchers investigate people's needs and routines in terms travelling with mobile devices. The purpose is to develop the knowledge which can help to create better mobile application solutions for the travellers. An online survey was conducted which was targeting travellers in Oslo and Trondheim. The survey lasted from September to October 2013. The survey reveals a lot of interesting patterns relating to people's travel routines. According to the similar access to mobile technologies and travel routines, researchers conducted a cluster analysis[5]

5 Cluster analysis: the task of grouping a set of objects in such a way that objects in the

and suggests four clusters:

- The first cluster ("Technology available") is also the biggest cluster (one third of the sample) based on the survey data. The cluster consists of travellers who have access to mobile technologies and are also well equipped with mobile internet. They are however not characterised as advanced users of mobile technology since they use mobile devices most for calls, messages and some browsing. This group of people usually rely on private cars for their daily travels.

- The second cluster ("Work and news") represents a quarter of the sample of the survey data. They are the travellers who are well equipped with mobile technology and are active users. They usually prefer functional activities such as email, messaging and reading the news. They also sometimes surf the internet and use social media, but the use is rather limited. They are usually active users of private cars as well. Men are significantly more than women is this group.

- The third cluster ("Active and social") represents a quarter of the sample of the survey data. They are younger travellers who travel a lot by public transport and are also very active users of mobile technology. Unlike the previous group, they are geared towards social networking, entertainment, music, etc. Women are more than men in this group.

- The final cluster ("Technology independent") represents almost one fifth of the sample of the survey data. They are the travellers who usually use mobile devices without internet. They also usually travel with no mobile technology whatsoever. Their mobile usage is very limited, usually only text messages and calls. Older men are the biggest population in this group.

The four clusters indicate the different needs and preferences of the travellers. It can be used as a framework for the development of new mobile applications for public transport. In this thesis, the four cluster framework will be used as the theoretical basis for the choice of interviewees. This will be specifically discussed in chapter 5.

My part of the work is to write a review about mobile applications for

same group (called a cluster) are more similar (in some sense or another) to each other than to those in other groups (clusters). Source: https://en.wikipedia.org/wiki/Cluster_analysis

public transport on the market. The purpose of the review is to generate an overview for the mobile applications which affect people's travel routines nowadays. The review meant to provide some insights and inspirations to the future development of mobile applications and eventually contribute to the improvement of people's travel experiences.

The project also organized an open innovation workshop in Oslo in 2014 spring, called Travel Hack 2014. This is a workshop that encourage and generate new innovative ideas that can give people better public transport travel experience with the help of mobile technology. Among all the new ideas for mobile application, three concepts appeared to be outstanding. They are *Sidespor*, *Travel Partner* and *GeoRuterWiki*. The researchers then evaluated the three concepts through focus groups. The focus group study shows that the concepts have the potential to improve people's travel experience. Moreover, everyone in the focus groups believes that their travel routines have changed over time due to the development of mobile technology. In another word, the mobile technology has made travelling more enjoyable and less boring for them. This discovery coincides with the hypothesis the study holds from the beginning: mobile technologies has been affecting most people's travelling experience.

The focus group study reveals some challenges and opportunities for transport providers. One of them is the expectations of many travellers that they can get updated information of transportations both before and during the travelling. This is so far challenging but also is an opportunity for big improvement of people's travelling experience. Based on this challenge, this thesis is going to conduct investigation into travellers' routines and needs regarding using public transport and mobile technologies. The purpose of the investigation is to look for possible design solutions to the problem of *information overload* and to cater for travellers' various of needs.

Chapter 3. Theoretical Considerations

In this chapter I will first present *Human-Computer Interaction (HCI)* as the research field of this study. Then I will lay forth the theoretical perspective of the problem: *information overload.* Further I will introduce several theories or technologies that are suggested by other authors as the possible solutions for *information overload*. Finally I will look at a few mobile application design considerations that are important for this study.

The structure of the theoretical considerations is as follows:
1. The research filed: *Human-Computer Interaction (HCI)*
2. The problem of *information overload*
3. Possible solutions for the problem of *information overload*: *presence awareness*, *context-aware computing*, *ubiquitous computing*, and *wearable technology*
4. Mobile application design considerations: *mobile technology*, *design thinking*, *user experience*, *usability*, and *universal design*

3.1 The research field: Human-Computer Interaction (HCI)

First and foremost, this study belongs to the research field: *Human-Computer Interaction (HCI)*.

The concept of *Human-Computer Interaction* originated from as early as the beginning of the 20s century where a systematic study of human performance with the machines in the factories has been taken place. Later on while the computer use gets more widespread, the topic around the interaction between machine and human-beings become more and more interesting as well as important, therefore more researchers started involving with this topic (Dix et al., 2003).

Nowadays, *HCI* is defined by the Association for Computing Machinery as follows:

> Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them. (The Association for Computing Machinery, n.d.)

Based on the nature of *HCI*, which studies human and machine in communication, *HCI* is composed of supporting knowledge from both the human and the machine sides. As a result, the study of *HCI* covers a wide range of research disciplines. It is not possible to design an effective interactive computer system within one solo discipline. The input has to be from all sides (Dix et al., 2003). According to Carroll (1997), *HCI* is an area of intersection between psychology, social sciences, and computer science and technology.

To be more specific, *HCI* as a multi-disciplines area touches upon the following disciplines:

- Psychology and cognitive science for understanding the user's behaviours, perceptions, skills, etc;
- Ergonomics for understanding the user's physical capabilities;
- Sociology for understanding the users in a wider context;
- Computer science and engineering for building the necessary technology accordingly;
- Business for marketing the product;
- Graphic design for producing effective interfaces;
- Technical writing for generating the manuals
- etc. (Dix et al., 2003)

Within the term *Human-Computer Interaction*, the *human* (user) can be

individual, group, or a sequence of users; the *computer* can be any technology ranging from small computer devices to large-scale computer system; the *interaction* means any form of communication between the user and the computer (Dix et al., 2003). Unlike other tools which have more specific and limited uses, such as glass is useful for containing liquid drink but not much else, computer can be used in many different ways. The dialog/interaction between human and computer is also usually open-ended (Card et al., 1983). The crucial element of this dialog/interaction is computer interface[6]. The interfaces can be in the form of *Graphical User Interface (GUI)*, *Voice User Interface (VUI)*, etc.

Much of the study of *HCI* seeks different methods for improving the interaction between the human and computer by improving the computer interfaces. Therefore, design of the interfaces is at the core of improving *human-computer interaction*. This study seeks design solutions for mobile interfaces: How to design a mobile application of public transport to meet travellers' needs, including getting updated information, and how to avoid *information overload* while providing the information.

3.2 The problem of Information overload

The use of mobile technology can sometimes lead to a paradoxical effects where people on one hand gain more freedom and independence to move around without losing awareness of the information happening, while on the other hand inevitably being leashed with the work-place, family issue, friends circle through the connection of mobile devices. Moreover, the boundaries between work and family, night and day become blur because people are pretty much available by their mobile devices 24/7. In another word, mobile technology brings people more freedom to move around without losing awareness but at the same time deprives their freedom to be unavailable and unaware (Arnold, 2003). To make it worse, not only people need to be available almost all the time, people are required to process an increasing amount of information at each moment. Some are relevant, some are irrelevant; some are emergent, some are unnecessary. Like Eriksen once described (2001): people are expected (by themselves, by the bosses, by friends and family, by the society) to process all the information that are

6 Computer Interface: In computing, an interface is a shared boundary across which two separate components of a computer system exchange information. The exchange can be between software, computer hardware, peripheral devices, humans and combinations of these. Source: https://en.wikipedia.org/wiki/Interface_(computing)

received by the mobile devices.

Who would expect the time-saving technologies would actually cause our time to be scarcer than ever (Eriksen, 2001)? This question trigger me to dive into a deeper investigation about the phenomenon.

3.2.1 Phenomenon/Definition

The term *information overload* was first mentioned in Bertram Gross's book "The Managing of Organizations" (Gross, 1964). Then the concept was popularised by Alvin Toffler in his book "Future Shock" (Toffler, 1984). It describes the situation where a person having difficulties understanding the issue or making decisions upon that due to the fact of being exposed to too much information.

> Information overload occurs when the amount of input to a system exceeds its processing capacity. Decision makers have fairly limited cognitive processing capacity. Consequently, when information overload occurs, it is likely that a reduction in decision quality will occur. (Speier et al., 1999, pp: 338)

Information overload can occur to different entities such as human-being, systems, organisations, etc. Butcher (1995) in his work pointed out, researches into *information overload* usually focus on three dimensions based on the receiver type: *personal information overload, organisational information overload,* and *customer information overload*. *Personal information overload* deals with the issues of how people react, make decisions and solve problems while confronting a large amount of information. Both technological and behavioural solutions are recommended. *Organisational information overload* focus more on the usage of information system in organisations. *Customer information overload* investigate the customer purchasing behaviour under the circumstance (Jackson and Farzaneh, 2012) This paper is concerned with the user behaviour regarding public transport applications, so that the personal coping system with *information overload* is at the centre of the research. Therefore I will only be discussing about *personal information overload* and the possible solutions to it.

Information overload is also a phenomenon across many different disciplines. Researchers from different disciplines give *information*

overload different understandings and explanations based on their fields which vary from psychology, information system, computer science, marketing, to organisational studies, sociology, accounting and so on. In this paper, the main focus will be *personal information overload* regarding using mobile devices.

3.2.2 In the light of the current information age

In early history, *information overload* was once mostly related to the over production of books (Wellmon, 2012) As the modern information age approaching since the second half of the 20th century, information becomes the most important entity in the knowledge economy. Nowadays, with the help of internet, information is available at a simple click or a swipe. Informations come in different forms on different devices.

There are two types of *Sources of Information* an individual or system receives from. They are either *pulled information* or *pushed information*. *Pulled information* is information that is available to be searched for and used when required by the recipient. *Pushed information* is information that people receive without having much control over (Jackson and Farzaneh, 2012). In the mobile device context, *pushed information* can also be referred as *push notification*. *Push notification*, is the delivery of information from a software application to a mobile device without a specific request from the user. *Push notification* can be received even when the application is not opened (Rouse, n.d.). Typically, *push notification* will make a sound and pop up on the screen. Users can normally also choose themselves which type of alert they want. *Push notification* is widely used by mobile applications and is generally accepted as one of the keys to keep users coming back (Finlay and McMahon, 2015).

While enjoying the convenience of obtaining informations, people are also suffering from the flood of distracting and unmanageable information coming in the form of instant messages, social network updates, email informations, etc (Hemp, 2009). The sources of these disturbing informations are usually from *push notification*.

Loads of *push notifications* can create a typical chaotic situation as follows:

> With the information floodgates open, content rushes at us in countless formats: Text messages and Twitter

> tweets on our cell phones. Facebook friend alerts and voice mail on our BlackBerrys. Instant messages and direct-marketing sales pitches (no longer limited by the cost of postage) on our desktop computers. Not to mention the ultimate killer app: e-mail. (I, for one, have nearly expired during futile efforts to keep up with it.) (Hemp, 2009)

Therefore, in the context of using mobile devices, *information overload* is also *push notification overload* to a certain extent.

To make it worse, people also have the tendency to not dare ignore some certain informations even though they are not directly addressed to themselves. These informations usually did not exist or was not accessible in the past, such as newest reports, social updates from friends and colleagues, blogs from friends and colleagues, discussions on the social networks that one follows, etc (Hemp, 2009).

People end up generating the stress of wanting to deal with every single information they receive but simply are not able to process every single one of them. People become overwhelmed and stressed. Some study even claims that this can lead to a decrease of people's intelligence (Hemp, 2009). As the world moving even more towards globalisation, the usage of information technology will only be more and more attached to people's daily lives. More and more people are becoming active users of the information technology (Jones, 1995). Meanwhile, information technology is also approved to be a source of interruption in the work environment (Speier et al., 1999).

3.2.3 Influential factors

The amount of information, i.e., *information quantity* is usually addressed as the major cause for *information overload*. Whether *information quantity* is the only reason for *information overload* is worth discussing (Ho and Tang, 2001) .

Ho and Tang (2001) investigated five industry cases, Energy & Utility, Pharmaceutical, Financial, Publishing, and Logistics, and found out *information quantity* is generally identified as the primary source for *information overload*. However, simply reducing the quantity of the information does not ultimate solve the problem of *information overload*.

They found out that the high volume of noise in the information, i.e., low *quality of the information* and the *information format* also contribute greatly to the phenomenon of *information overload* even if the quantity of the information is reduced. Therefore, they identified three common *information overload* factors:

- *Information Quantity*
- *Information Format*
- *Information Quality*

Three dimensions, in combination, contribute to the problem of *information overload*. The following figure shows this relationship:

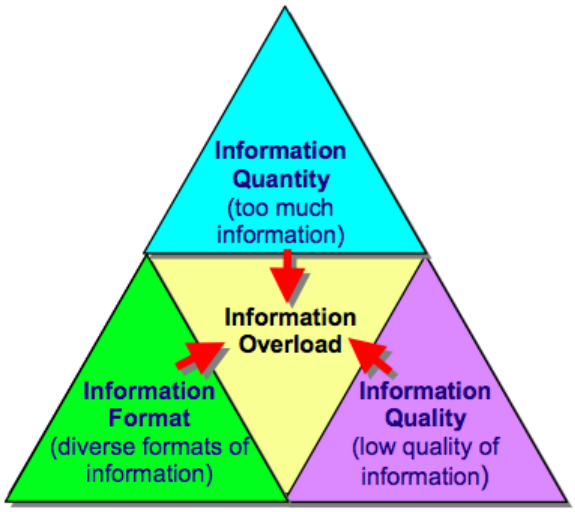

Figure 3.1: Dimensions of information overload (Ho and Tang, 2001, p. 93)

The authors suggest that the three dimensions are having the same significance in contributing to the phenomenon of *information overload* (Ho and Tang, 2001).

Similar discoveries can be found in other research works as well. Ho and Tang's concept model is repeated and also expanded over the years.

Jackson and Farzaneh (2012) derived some key definitions, situations and fundamental components of the overload problem from others' work and came up with a model which analyses the situation of whether or not *information overload* occurs and under what circumstances *information overload* would happen. They first categorised the factors that influence

information overload into three categories based on their direct or indirect effect on *information overload*.

1. Instinstic factors
- *Quantity of Information*: the available information that is accessible for the individuals;
- *Information Processing Capacity*: refers to the phenomena that, due to the limitation of human brain that has been scientifically proved, people can only process a certain amount of information at the same time;
- *Available Time*: the amount of time for task performance.

2. Extraneous factors
- *Characteristics of Information*: level of complexity, ambiguity, novelty, intensity and uncertainty associate with the information;
- *Quality of Information:* how well the information meets the need of the users, i.e., information usefulness. It's assembled by two factors relevance and validity;
- *Task and the Process Parameters*: characteristics of the tasks such as novelty, complexity, multi-tasking, task interruption. Task novelty and complexity may increase task processing pressure. Multi-tasking and task interruption may decrease the task processing capacity.
- *Personal Factor*: personal experience in the field, personal skill level such as reading the analytical speed, cognitive style, personal habits of gathering the information, etc.

3. Intrinsic and extraneous factors
- *Sources of Information*: the variety of information sources that are available for people. Some are *pushed information* which people have little control over, some are *pulled information* which people have greater control over.

The authors then consider all these factors as the contributor units and *information overload* as an event that depends on these contributor units. Therefore, they draw a *information overload* model which is consisted by seven units:
Unit 1: *Quantity of Information*
Unit 2: *Characteristics of Information*
Unit 3: *Quality of Information*
Unit 4: *Information Processing Capacity*
Unit 5: *Available Time*

Unit 6: *Task and the Process Parameters* are made up of multiple factors combining task novelty, task complexity, multi-tasking and task interruption
Unit 7: *Personal Factors* are made up of multiple factors combining level of prior experiences, personal skills, cognitive style, motivation of the person, and personal situation.

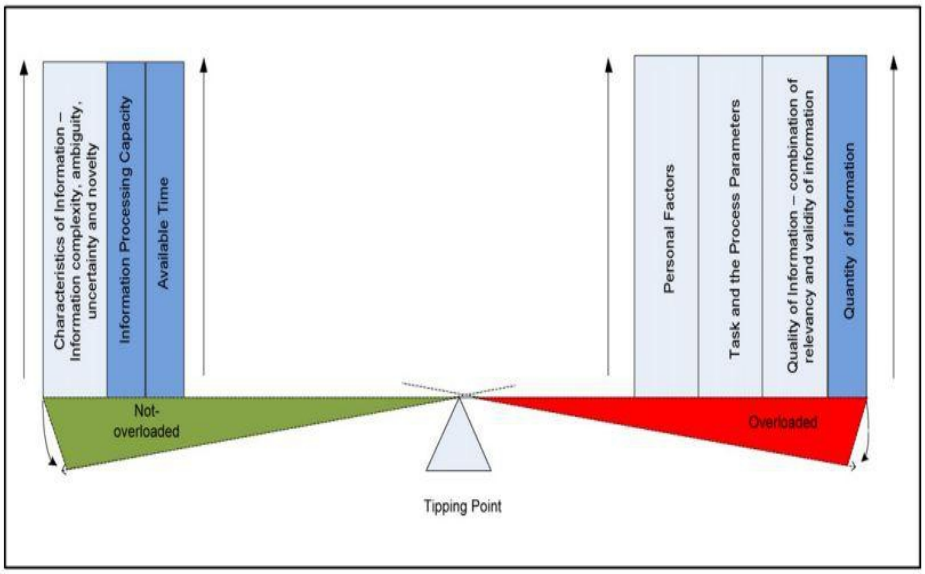

Figure 3.2: The conceptual information overload model. (Jackson and Farzaneh, 2012, p. 528)

In the model, the seven units are divided into two groups: "for" factors (to the right) which increase the likelihood of *information overload* occurring and the "against" factors (to the left) which lessen the possibility of *information overload*. Tipping point is the point when *information overload* occur. Moreover, the seven units are not entirely independent from each other (Jackson and Farzaneh, 2012):

- *Characteristics of Information* has a relationship with *Information Processing Capacity* and *Personal Factors*;
- *Quality of Information* has a relationship with *Quantity of Information* available, and also associates with *Information Processing Capacity* and *Available Time*;
- *Information Processing Capacity* can't be separated from *Personal Factors*;
- *Task and the Process Parameters* associates with *Information Processing Capacity*.

Therefore, all the factors are in fact working together either increasing or decreasing the level of *information overload*.

The model provides a good theoretical foundation for considering possible solutions for the problem of *information overload.*

3.3 Possible solutions for the problem of information overload

In the context of using mobile technologies, several authors have already suggested a few possible solutions to the problem of *information overload*.

3.3.1 Presence awareness

Spira suggests in his book (Spira, 2011) that keeping your *presence awareness* up-to-date could be an efficient way to lower *information overload*.

Presence is users' level of availability for dealing with information. *Presence awareness* is the knowledge of the users' presence, i.e., knowing whether the users are available to deal with information. It can be a statement showing as status flag such as “Online”, “Busy” or “Away” (“What is Presence?”, n.d.). *Presence awareness* helps the users to organise their availability in terms of when to receive information. This avoids information coming at a un-welcome time for the users. Therefore, it helps to lower the possibility or the level of *information overload* (Spira, 2011). *Presence awareness* is commonly mentioned in the discussion for collaborative activities in the information age. Providing information about *presence awareness* is also the central function of many collaborative applications. Especially for many large and global organisations, know the level of others' availability is essentially important for a good and continued communication (Godefroid et al., 2000).

Apart from being useful for collaborative activities, *presence awareness* can be also applied to the case of users' level of availability for receiving information on the mobile phone. Some mobile applications such as calendars provide users the function of choosing a certain available time period for receiving *push notification* from the calendar. In this case, users keep their *presence awareness* up-to-date to a mobile application so that the

application knows about the appropriate time to send information to the users. This avoids the situation that users receive information when they don't want to.

3.3.2 Context-aware computing

Context-aware computing is the idea that mobile devices or mobile applications provide different services when the users are in different contexts. The contexts here usually strongly relate to users' location (Schmidt, 2014) and activity (Schmidt et al., 1999).

However, as the definition for context as follow: "that which surrounds, and gives meaning to something else"[7], context has a very broad meaning and should refer to many more things.

A model (Schmidt et al., 1999) structures a suggestion for the concept of "context" in the computer science field.

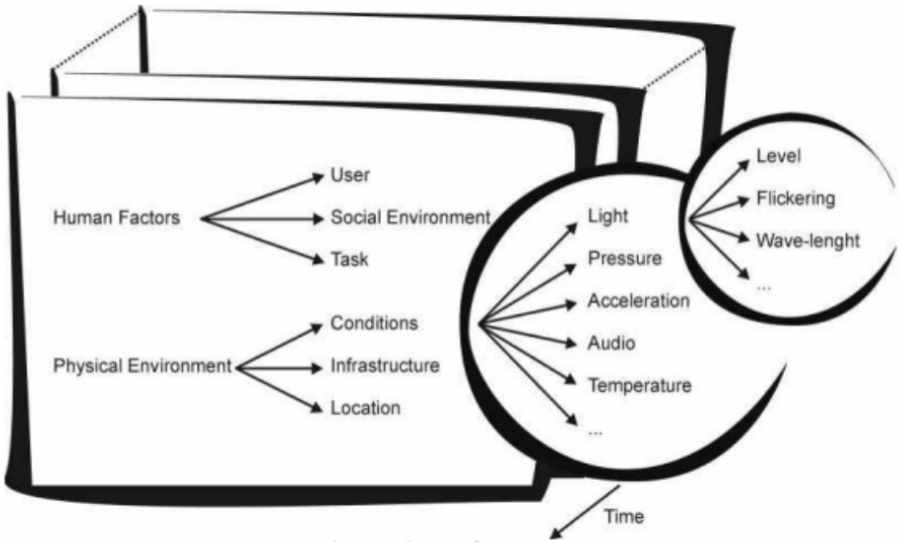

Figure 3.3: General structure of context (Schmidt et al., 1999, p. 3)

The model identifies two general categories of factors that structure context. Each category is divided into three more groups:

- Human factors refers to: the information of the user (knowledge

7 Definition of *context* in "The Free On-line Dictionary of Computing". Source: http://dictionary.reference.com/browse/context?s=t

habits, experience, emotional status, etc); the user's social environment (social interaction, group dynamics, etc); and the user's tasks (general goals, engaged activities, etc)

- Physical environment refers to: location (absolute location, relative location, co-location); infrastructure (resources of computation in the environment, communication, etc); physical conditions (noise, light, etc)

To acquire the context information, the mobile application either ask the user to specify it himself/herself, or monitor the user's locations and activities. For monitoring user's locations and activities, mobile devices commonly utilise GPS system[8], Wi-Fi[9], Cell ID[10], etc (Lawson, 2012).

By gaining context-awareness, mobile devices or mobile applications have the opportunity to adjust their pattern of providing information according to the specific context the users are in. It can meet users' need better in the sense of providing appropriate information in the appropriate context. It saves users' trouble of processing unnecessary information in a certain context which have the potential to decrease the risk of experiencing *information overload*.

3.3.3 Ubiquitous computing

Information technology nowadays has allowed us to step away from the stationery computer and freely enjoy the computing technology on any of the devices (mobile phone, tablet, laptop, etc) at any of the locations (home, office, beach, mountain, etc), and in any format (Ling, 2014), i.e. *ubiquitous computing*. Coined by Mark Weiser in his article “The computer for the 21st century” (1991), *ubiquitous computing* envisions computers seamlessly integrate into the environment and communicate with each other. Weiser (1991) suggests to conceive a new way to think about computers in the world, one that takes into account the natural human environment and let the computers vanish into the background. It's also based on human psychology which suggests that when people learns something sufficiently well, they cease to be aware of it. In another word, *ubiquitous computing* allows people to enjoy the computers in their lives without being aware of the sophistication of the computing systems around them. Computers will be seamlessly integrated into people’s lives.

8 GPS system: Global Positioning System
9 Wi-Fi: A local area wireless computer networking technology
10 Cell ID: The ID of each mobile phone.

Information is available at fingertips no matter where you are and what you are doing.

Based on these characteristics, Weiser (1991) envisions that *ubiquitous computing* will help overcome the problem of *information overload*.

> Machines that fit the human environment instead of foxing humans to enter theirs will make using a computer as refreshing as taking a walk in the woods. (Weiser, 1991, p. 8)

Similar ideas have also being mentioned by other authors regarding the design of computing systems. Donald Norman says in his book "The Design of Everyday Things":

> In fact, the best computer programs are the ones in which the computer itself 'disappears', in which you work directly on the problem without having to be aware of the computer. (Norman, 2002, p. 180)

The book "Web UI Best Practices: UI Design from the Experts" mentioned the idea of disappeared technology regarding the design of *User Interface (UI)*:

> ...the better a UI is, the less you notice it. Just like a good film makes you forget you're in a theatre, a solid UI will immerse the user in the experience and not draw attention to itself. Not even noticing the UI produces the best UX. (Bank and Cao, n.d., p. 16)

The key word here is *disappear*. Similar opinion have been expressed by different authors that, a good design for technology is to make the technology seamlessly integrate into people's lives, in another word, disappear to the background. The less requirement of people's active attention to obtain information has the potential to reduce the chance of *information overload*.

3.3.4 Wearable technology

Wearable technology refers to the technology that enables the integration of computer or electronic technologies and the items people can wear on their body in daily life, such as clothing or accessories. These wearable devices

can perform the same tasks as computers can do. In the mean time, wearable devices are able to do more since they can provide sensory and scanning features which are usually not existing in the traditional mobile devices, such as biofeedback and tracking of physiological function (Tehrani and Andrew, 2014). The common examples for wearable devices are watches, glasses, contact lenses, smart fabrics, caps, bracelets, etc.

Wearable devices traditionally refer to the items that are easily take on and take off from the body, such as watches and glasses. However, there are also the emerging trend for the design of more invasive types of wearable devices such as implanted micro-chips or smart tattoos. According to Tehrani and Andrew (2014), whether invasive or not, the ultimate goal of the wearable devices is to provide the users seamless, hands-free, convenient and portable experience of accessing electronic or computer technologies. The experience of smoothly incorporate the usage of technology and people's daily lives.

The prediction for the development of *wearable technology* is quite optimistic. Many have the vision that the *wearable technology* nowadays will just be like mobile technology 20 years ago, who smoothly integrate into people's daily lives just in a couple of decades (Tehrani and Andrew, 2014). As a matter of fact, more and more people have already started using various types of wearable devices. For example, smartwatch is one type of wearable devices that has become more and more popular in the last a few years. Some smartwatches pair with user's other computing devices such as smart phone, tablet, PC, etc, and share data with each other.

Android Wear[11] is an operating system which is designed for smartwatches and other wearables. Android Wear created a new concept *glanceability*, meaning users can get information *at a glance* by using wearable devices with Android Wear (“Android Wear,” 2015). In another word, users don't need to pay too much active attention to get information from the devices. This potentially lowers user's risk of feeling *information overload*.

3.4 Mobile application design considerations

In *HCI*, there are a lot of design principles that designers need to follow. In this study, the focus is on how to design mobile application. Accordingly,

11 Android Wear's official website: https://www.android.com/wear/

there are a few design principals I consider as important to this study.

3.4.1 Mobile technology

Mobile technologies, is also known as portable information and communication technologies (ICTs). It was developed as an attempt to better service people in mobile activities, which allows people to not be limited in one single location during the use of computer technologies (Wiredu, 2007). Mobile computing is enabled by communication technologies in various of forms such as Wi-Fi, Bluetooth[12], 3G[13], 4G[14], GSM[15], dail-up services[16] and so on. Mobile technology is implemented in the form of mobile IT devices such as laptop, tablet, smart phone, GPS devices and wireless payment terminals (Migrator, 2000).

Apart from providing the flexibility of switching locations while using computer devices, the mobile technologies also enable personalization as to serve personal motives. Mobile devices can be carried by the users to anywhere at anytime. This contrasts to the scenario where people have to use the traditional computer devices such as desk-top computers at a certain location and a certain time (Wiredu, 2007).

The usage of mobile technology among people has been growing rapidly in the last a few decades and is still keeping a high growing pace ("Mobile Phone Users Worldwide 2012-2018 | Statistic", 2015). For example, statistic shows that in US, the ratio of digital media time adult users spend on mobile devices has now exceeded desktop and other media, reached a point of 51 percent ("Mobile Marketing Statistics 2015", 2015).

However, there is also the concern of security issue along with the ever popular usage of mobile technologies. Mobile devices can contain essential information of the users. By using mobile devices, users are under the risk of exposing these informations (Migrator, 2000). For example, the mobile devices can contain user's credit card information in addition to all the other

12 Bluetooth: Wireless technology standard for exchanging data over short distances.
13 3G: short form of third generation, is the third generation of mobile telecommunications technology.
14 4G: short for fourth generation, is the fourth generation of mobile telecommunications technology, succeeding 3G.
15 GSM: Global System for Mobile Communications.
16 Dial-up services: data networking services using modems and telephone lines.

private identification information. Therefore, the risk of exposing users' sensitive information is extra high and the responsibility of protecting the users' privacy is significantly bigger. Authentication schemes is one of the ways to lower the risk of the devices being misused by any unauthenticated or unauthorized users. Many existing authentication schemes include traditional password, PIN-based authentication, graphical password, fingerprint, face, voice, handwriting and so on (Schlöglhofer and Sametinger, 2012).

Mobile technology composes the foundation of this study, as the study is seek for design solutions for mobile application. It is important to bear in mind with the knowledge of mobile technology when conducting the research.

3.4.2 Design thinking

Design thinking is a user-centered approach, meaning a deep understanding for users' needs and motivations is needed for any phases of the design process as the users are the centre of the product. *Design thinking* is becoming more and more popular and the lack of *design thinking* is also considered as one possible reason for the failures of many projects (De Paula et al., 2014). This study aims at solving the design problem through investigating user's routines and needs regarding using public transport and mobile technologies. Therefore getting deeper understandings into user's behaviour is the key of this study. *Design thinking* is absolutely important to be taken into account.

3.4.3 User experience

User experience (UX) usually refers to people's feeling while interacting with the product (De Paula et al., 2014). A variety of factors influence the experience of the interaction evokes (Arhippainen and Tähti, 2003).

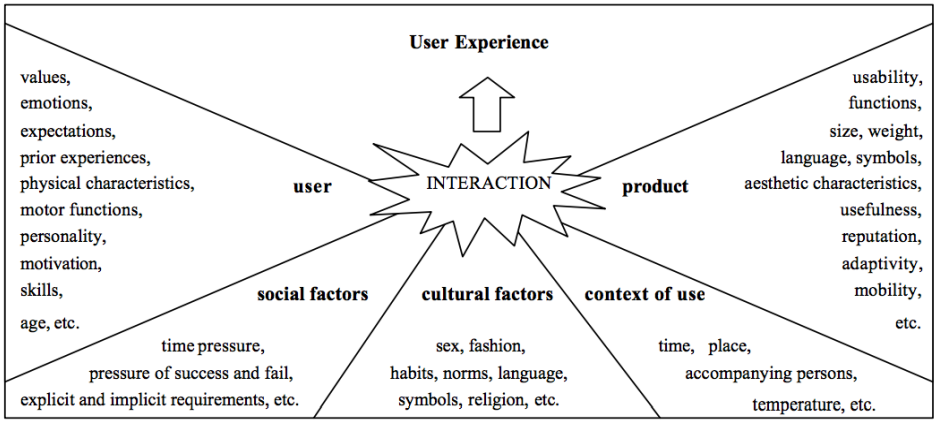

Figure 3.4: User experience forms in interaction with user and product in the particular context including social and cultural factors (Arhippainen and Tähti, 2003, p. 28)

Social factors, cultural factors and context of use, together influence the interaction between user and product, which in the end create *user experience* (Arhippainen and Tähti, 2003). It is a complicated system which forms the *user experience*. Therefore, a lot of factors need to be taken into consideration when designing the product in order to create positive *user experience*.

A good *user experience* is what the designers pursue. According to Roto (2013), a good *user experience* requires the product to be both functional and emotional.

For capturing the *user experience*, several methods are used in the research activity. Arhippainen and Tähti (2003) mentioned a few methods such as interviews, observation, surveys, diaries, storytelling and prototyping, etc.

3.4.4 Usability

According to ISO[17]'s definition regarding *usability*,

> Usability refers to the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified

17 ISO: International Standard Organization.

context of use.

The *usability* guidelines presented by ISO, Nielsen(1993) and Shniederman(1997) are most widely accepted and cited (De Paula et al., 2014).

ISO	Nielsen	Shniederman
Effectiveness	Consistency and standards Error prevention	Strive for consistency
Efficiency	Flexibility and efficiency of use Aesthetic and minimalist design Help users recognize, diagnose, and recover from errors	Design dialog to yield closure Offer simple error handling Reduce short term memory load
Satisfaction	User control and freedom Visibility of system status Match between system and the real world Recognition rather than recall Help and documentation	Offer informative feedback Enable frequent users to use shortcuts Permit easy reversal of actions Support internal locus of control

Table 3.1: Usability guidelines by ISO, Nielsen(1993) and Shneiderman(1997) (De Paula et al., 2014, p. 316)

Usability testing is the measurement for *usability*. Usability testing will be discussed in chapter 5.

3.4.5 Universal design

Universal design aims at designing the product so that it can be used by the widest range of people as possible. Evolved from Accessible design, which addresses the need of disabled people, *universal design* reckons a wider range of people's abilities. Therefore, *universal design* bears the full range of human diversity in mind and strives to design the product so it can be easier for all people to use ("What is Universal Design?," n.d.).

The Centre for *Universal Design* at North Carolina State University proposed several principles for *universal design* ("Universal Design Principles," 1997):

- Equitable use

- Flexibility in use
- Simple and intuitive
- Perceptible information
- Tolerance for error
- Low physical effort
- Size and space for approach and use

Travellers of public transport can be of various of ages, needs, routines, etc. It is important to take *universal design* into account. Especially during travel, the need of being able to use the mobile application efficiently is normally even stronger than usual. The design should cater for as large group of people as possible.

3.4.6 A review of the mobile applications for public transport

As part of the project *Mobile Applikasjoner Underveis*, I did a review of the existing mobile applications for public transport on the market (Julsrud et al., 2014). The purpose of the review is to generate an overview for the mobile applications which affect people's travel routines nowadays.

According to certain rules of selection[18], I reviewed a total number of 30 popular mobile applications and put them into four categories:

- City public transport planning

RuterBillett, RuterReise, Google Map, Moovit, Flytoget, Oslo Airport, AtB Mobillett, Skyss Billett, Skyss Travel (Skyss Reise), TripAdvisor Hotels Flights

- Between city public transport

NSB, Nettbuss.no, Norwegian Travel Assistant, SAS Scandinavian Airlines, Ryanair

- Navigation

GPS Navigation BE-ON-ROAD, DigiHUD Speedometer, Google Earth, Gule Sider Navigasjon, NaVida, Waze Social GPS Maps & Traffic

- Private transport

EasyPark, SmartPark Trondheim Parkering, Norgeskart, UT.no turguide, Uber, Strava Running and Cycling GPS, Endomondo Running Cycling Walk, Moves, Foursquare

The review is based on the user comments and ratings in several popular

18 The specific reasons for selection are explained in the report. Link to the report: https://www.toi.no/publikasjoner/mobile-applikasjoner-underveis-hva-onsker-de-reisende-article32965-8.html

online application stores. Several issues are discovered as the most frequently complaints by the users:

- Stability: often crashes; server error;
- Data storage: losing data;
- Usability: difficult to use some functions;
- UI & UX: unsatisfactory design. Many users mentioned the words UI, UX or Usability specifically;
- Offline performance: stored maps, stored tickets, etc.

The review provides some insights into the performance of the popular mobile applications for transport on the market today. These insights can be valuable implications for the future development of the mobile applications in the transport domain.

Chapter 4. A Design of Mobile Application

Based on the theoretical considerations (in chapter 3), and inspired by Android Wear's concept *glanceability* (“Android Wear,” 2015), I designed a mobile application *Trafficker.Trafficker* is an application that sends users the updated information about public transport.The purpose of designing this application is to further test the theories, technologies, and the *glancebility* design concept. *Trafficker* borrows idea from the TV news ticker and aims at updating the users with public transport information *at a glance*. In another word, the application aims at providing users the updated information in a seamless way which potentially decrease the chance of *information overload*.

In this chapter, the design process of *Trafficker* will be presented. *Trafficker* will be tested by four users in the usability tests. The specific discussion about the usability test will be conducted in 5.3.2 Usability test, Chapter 5. Through the usability test, users access the problem from a different angle. It helps the users to understand some of the design concepts better with a real-life model: *Trafficker*. Hopefully users will also provide more insights on the issue and help the researcher to understand their needs and routines better.

The design process of *Trafficker* includes three phases:

- Conceptualising
- Non-functional prototype

- Functional prototype

Each of the phases will be discussed in the following sections.

4.1 Conceptualising

Main design concept of the application is to realise the function of a ticker providing updated information. In addition, I want the application to allow users to adjust their presence information and context information.

In order to provide the updated information in a seamless way, I will locate the ticker on the home screen in the form of a widget. The existence of the ticker would not affect users interacting with other applications. The information showed by ticker will not be sound alerted.

In order to allow users to adjust their presence and context information, the application will have the setting section where users can choose their available time period and geographical area of interest. The setting will also allow users to choose the public transport routes they are concerned about.

Technically, *Trafficker* will be built as a web application. There are several reasons for this choice:

- Web application is cross-platform
- Web application is easy to build and has a lot of available tools to utilise
- I work as a web developer besides study. Therefore I'm most familiar and comfortable with web technologies.
- The main purpose of creating the application is to test the theories and technologies, as well as the *glancebility* design concept, in order to explore the research questions. The web application will be able to serve this purpose with its functionalities.

The data source of the application is mainly from the open data of public transport from Ruter[19].

4.2 Non-functional prototype

Mobile type and the screen size are the things we cannot control when

19 Ruter open data, see: http://labs.trafikanten.no/aapne-data.aspx

designing mobile applications. However, we can control how comfortable the design is to use in different environments (Cao, 2015). The following figure shows this design consideration:

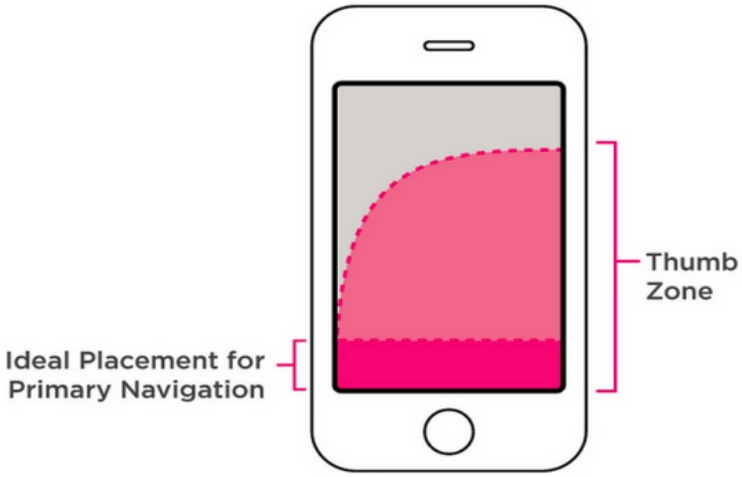

Figure 4.1: Thumb zone mobile design concept. Photo Credit: Rosenfeld Media, Creative Commons 2.0[20]

Thumb zone is the area on the mobile screen which is easily accessible to all the users with different hand size. The ideal navigation area fits to the thumb pattern when clicking or swiping (Cao, 2015). In this research, I am designing the mobile application for people to use before or while travelling. In travelling situation, it is often possible that people are in a multi-tasking situation while using the mobile application. Their concentration level can be low. Their time can be limit. They can be carrying things which means they would not have both hands available for operating on the mobile devices. Therefore, in the travelling situation, how to design the mobile application to be convenient enough for the users is significantly important than in many other situations.

20 Source: https://www.flickr.com/photos/rosenfeldmedia/7171779486/in/photolist-bVKfbs-7ijKGV

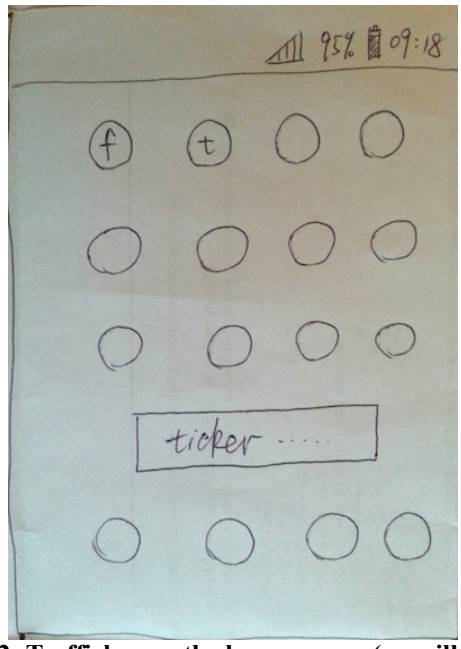

Figure 4.2: Trafficker on the home screen (own illustration)

Trafficker will be shown on the home screen as a widget in the form of a ticker. When there's updated information about the transport route the users concern about, information will be shown in the ticker section. If there're more than one updated message, all the messages will be displayed in the form of scrolling text running from bottom to top across the section. If there's no updated information at the current time, the ticker section will be blank. User can freely access to other applications on the phone. The ticker will only be visible every time the user is on home screen.

When click on a specific message in ticker section, more information about this specific message will be shown as follows:

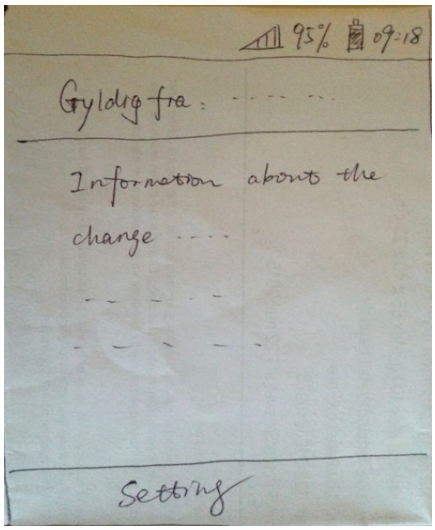

Figure 4.3: More information page (own illustration)

The more information page shows detailed information about the updated transport condition. It includes information about the time period this condition lasts, the specific explanation of the condition, the suggestion for alternative routes, etc.

At the bottom of the more information page, it's a button “Setting”. By clicking it, the user enters the setting section of *Trafficker*.

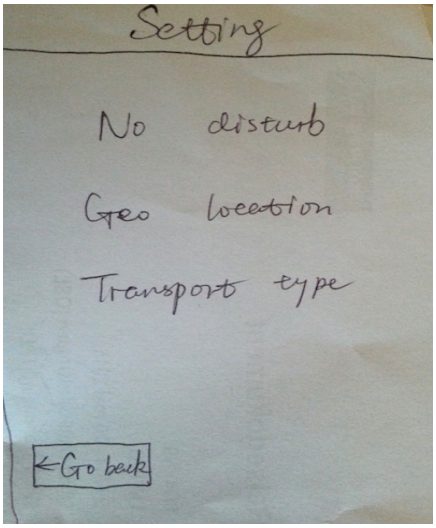

Figure 4.4: Main setting page (own illustration)

There are three options in the setting section that users can customise. They are “No disturb”, “Geo location” and “Transport type”. The “Go back” button navigates the user to the last section.

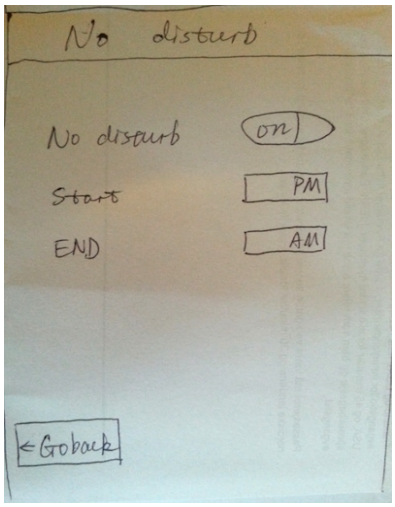

Figure 4.5: “No disturb” section (own illustration)

In the “No disturb” section, user can adjust their availability of receiving updated information from *Trafficker*. If the “No disturb” is off. No information will be shown on the home screen ticker no matter there's updated information or not. When the “No disturb” is on, the user can choose which time period of the day he/she is available for receiving informations.

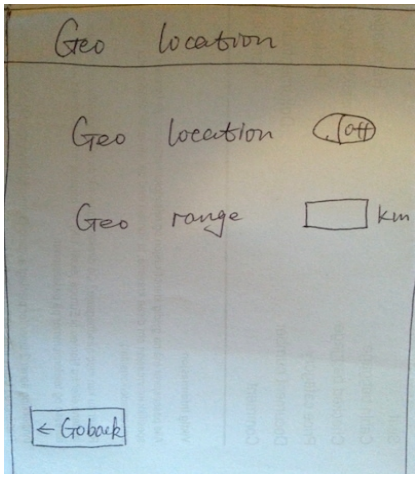

Figure 4.6: “Geo location” section (own illustration)

In the “Geo location” section, user can choose whether they want the application to detect their location. If the “Geo location” is off, user's location will not be detected. When the “Geo location” is on, *Trafficker* will first detect user's location, then draw a circle around the user's location. The radius of the circle is the “Geo range” user chooses himself/herself. When the circle is drawn, *Trafficker* will detect all the updated information concerning public transport in this circular geographical area. The information will be shown in the ticker section on home screen of the mobile phone.

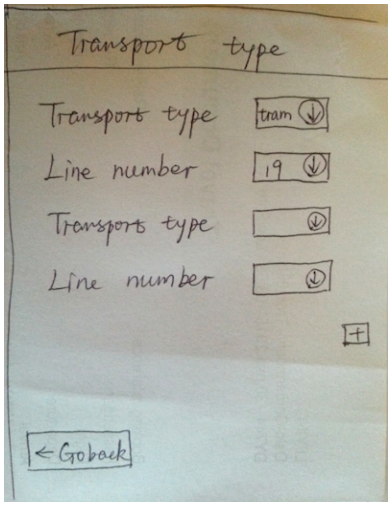

Figure 4.7: “Transport type” section (own illustration)

In the “Transport type” section, user can choose the specific public transport route they are concerned with. By choosing the transport type and the line number, one route is determined. All the updated information concerning this route will be shown in the ticker section on the home screen. User can choose as many routes as they want. By clicking the “+” button, two more lines with the option of transport type and line number will be shown.

4.3 Functional prototype

The functional prototype of *Trafficker* is a web application with dummy data. User can have a series of interactions with the application. These interactions cover the core function and design concept of *Trafficker*.

Here're the screenshot of each section of the application:

Figure 4.8: Trafficker on the home screen (screenshot)

Figure 4.9: More information page (screenshot)

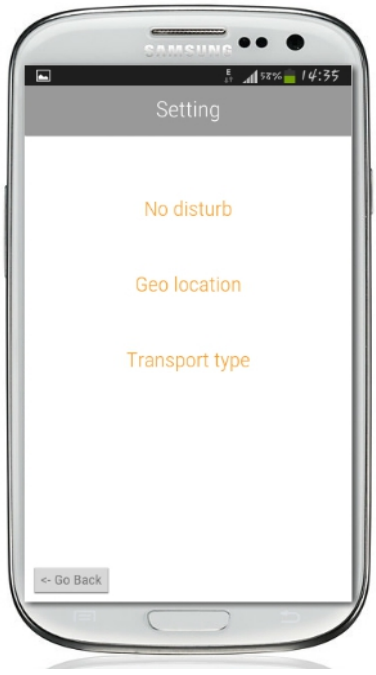

Figure 4.10: Main setting page (screenshot)

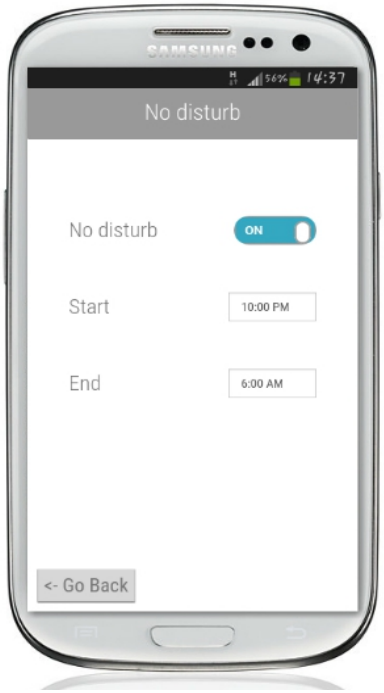

Figure 4.11: “No disturb” section (screenshot)

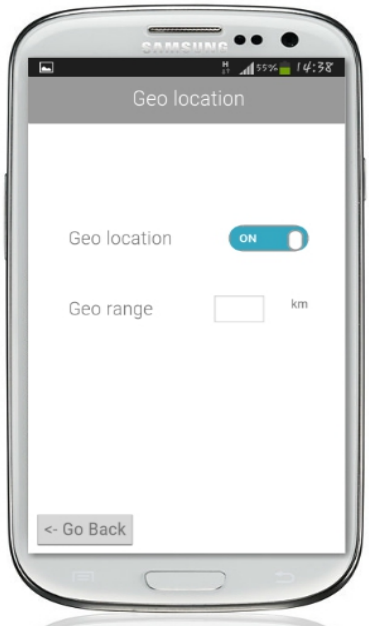

Figure 4.12: “Geo location” section (screenshot)

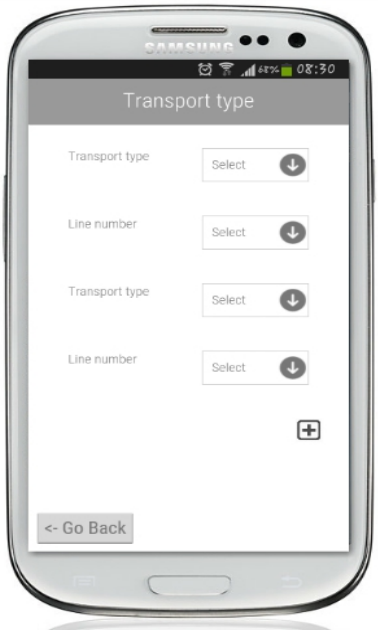

Figure 4.13: “Transport type” section (screenshot)

Chapter 5. Methods

This chapter presents the research methodology choices of this thesis. First of all, the thesis adopts empirical research method using qualitative research strategy. Interview, usability testing and ethnography study are conducted for collecting data. Then a content analysis will be applied to the data collected from the fieldwork. In the end I will discuss the reliability and validity of this study.

5.1 The choice of empirical method

Researchers see a trend of methodology change in the mobile *HCI* research since early 2000s. In the early 2000s, the mobile *HCI* research was primarily driven by engineering and applied science (Kjeldskov and Paay, 2012). A new system is usually build upon a trial-and-error manner and tested in laboratory settings. Little attention was paid to the real world context in relation to understanding, building and testing the interactive mobile systems (Kjeldskov and Graham, 2003; Kjeldskov and Paay, 2012). In another word, the focus of the design by then was more on the *systems* rather than the *people*. Three unfortunate assumptions conclude the characteristics of the mobile *HCI* research by then:

- "We already know what to build". The assumption is that we already know what to build and how to build in the perspectives of engineering and applied science, which almost has nothing to do with the user-perspective.
- "Context is not important". The assumption is that building and evaluating the interactive systems on the basis of applied science and engineering generate concrete solutions. There is no need for real-world

studies.

- "Methodology matters very little". Researchers found out that there were very few studies by then that was based on explicit methodological foundation. This indicates the assumption that methodology does not matter much (Kjeldskov & Paay, 2012, p. 70).

It is believed that this type of mobile *HCI* design by that time limits the possible quality improvement of the systems as well as the future development of the research field (Kjeldskov and Paay, 2012).

However the picture has gradually changed over the last a few years. In late 2000s, empirical methods are used more and more often in the mobile *HCI* research compared to the early 2000s. Nowadays, there is no single method that dominates the research field, like the applied science dominating the field several years ago. Instead, the research area has become multi-methodological. Mobile *HCI* research has become more balanced across a broader range of disciplines. The tendency of moving towards multi-methodological indicates the research field's gradual realisation of the importance of satisfying *people* and working closely with other disciplines. Moreover, methodology is considered as an important part in nowadays mobile *HCI* research in the sense that methodology is the basic guidance of the research focus and contribution (Kjeldskov and Paay, 2012).

This study's focus is users. To answer the research questions, I will conduct a series of investigations around users' routines and needs about using public transport and mobile technologies. To better understand the users is the key of this study.

5.2 Research strategy: Qualitative research

To make a choice of research strategy between quantitative research and qualitative research for my study, I first investigated the differences between the two strategies: Fundamentally,

- quantitative research emphasises quantification during the data collection and data analysis; entails a deductive method and aims at testing theory; focus more in classifying features therefore more conclusive in nature; usually use tools such as questionnaires, surveys to collect data.
- qualitative research on the other hand, usually emphasises words more than quantification during the data collection and data analysis; entails

an inductive method and aims at generating theory; focus more in providing complete description of the research topic therefore more exploratory; usually use the researchers themselves to serve as the primary data collecting tools (Bryman, 2008).

The main steps in qualitative research are:

- Step 1. General research questions
- Step 2. Selection of relevant subjects of study
- Step 3. Collection of relevant data
- Step 4. Interpretation of data
- Step 5. Conceptual and theoretical work, how to relate to the general research questions
- Step 6. Writing up findings/conclusions. (Bryman, 2008)

In this study, I want to understand the problem of *information overload* and then try to suggest possible design solutions for it. In order to deeply understand the problem, I need to conduct an in-depth study about the users. Instead of looking for classified feature in large population, my concern is to deeply understand the problem from user's point of view and look for possible solutions based on this understanding. Therefore, qualitative research strategy is more suitable for this study.

5.3 Data collecting methods

The data collecting methods that are usually used in qualitative research are ethnography/participant observation, qualitative interviewing, and focus groups (Bryman, 2008). Apart from that, usability testing is a technique used in user-centered design to evaluate a product which involves representative users conducting representative tasks in representative environments (Lewis, 2006; Lazar et al., 2010).

I'm adopting multi-methodological strategy in this study. Multi-methodology is more often used and a broader context is taken into consideration in the studies (Kjeldskov and Paay, 2012). This strategy is also referred as triangulation. Triangulation brings greater confidence in research findings, which results in increasing validity of the qualitative research (Bryman, 2008). I will use a combination of data collecting methods which are qualitative interviewing, usability testing and ethnography. The reason for choosing each of them will be explained in the

latter part of this chapter.

5.3.1 Interview

a) Why interview

This research primarily is to have a deep understanding into the phenomenon *information overload* in user's context. User's real-world behaviour, habit and preference are the centre of concern. Interviewing enables researchers the ability to "go deep". By asking questions that explores a wide range of concerns around the central problem and give interviewees the freedom to provide deep and detailed answers, researchers would be able to gather the data that is usually not easy to capture. Interviewing can be exploratory. Interviewees are encouraged to generate in-depth point of view and share reflective insights (Bryman, 2008). Therefore, interviewing is the suitable strategy for exploring the research questions in this study.

b) Type of interview

There are two main types of qualitative interviewing: unstructured and semi-structured interviewing. In the unstructured interview, researchers may use only one single question to start the conversation then let the interviewee speak freely. In the semi-structured interview, the researcher has a list of questions that should be conveyed, which is usually referred as interview guide. However, the interviewee has great deal of freedom in terms of replying. The researcher may raise the questions in a different way from the interview guide. Some new questions may be asked. Even so, in the end all the questions on the interview guide will be asked and similar wording will be used for each interviewee (Bryman, 2008).

I choose semi-structure interviewing as my interviewing strategy. It allows the freedom of exploring the research questions, but at the same time keep the topics in a certain range that are most related to my study.

c) Objects of interview: Four cluster framework

According to the various needs and preferences of the travellers, report "Mobile applications on the way – What do the travellers want?" (Julsrud et al., 2014) suggests grouping all the travellers into four clusters. Each cluster

of travellers share similar access to mobile technologies and travel routines. This four cluster framework helps mobile application designers to better understand travellers' different needs and preferences in order to design the mobile application to serve the needs of as large range of population as possible. This also coincides with the value of *universal design* (discussed in chapter 3). The four cluster framework as mentioned in chapter 2, is as follows:

- The first cluster ("Technology available") consists of travellers who have access to mobile technologies and are also well equipped with mobile internet. They are however not characterised as advanced users of mobile technology since they use mobile devices most for calls, messages and some browsing. This group of people usually rely on private cars for their daily travels.
- The second cluster ("Work and news") are the travellers who are well equipped with mobile technology and are active users. They usually prefer functional activities such as email, messaging and reading the news. They also sometimes surf the internet and use social media, but the use is rather limited. They are usually active users of private cars as well. Men are significantly more than women is this group.
- The third cluster ("Active and social") are younger travellers who travel a lot by public transport and are also very active users of mobile technology. Unlike the previous group, they are geared towards social networking, entertainment, music, etc. Women are more than men in this group.
- The final cluster ("Technology independent") are the travellers who usually use mobile devices without internet. They also usually travel with no mobile technology whatsoever. Their mobile usage is very limited, usually only text messages and calls. Older men are the biggest population in this group.

This cluster framework will be used as the theoretical basis for the choices of interviewees. From my own social network, I chose four people whose profiles (based on my knowledge) fit to each of the four clusters. To make sure each of their profiles fits to the category, I did a pre-interview to ask some questions about their routines of using mobile technologies and public transport. In order to protect the identities of the interviewees, I will codename them in this thesis. The four interviewees are:

- Interviewee A, male, 30 years old
- Interviewee B, female, 26 years old
- Interviewee C, female, 63 years old

- Interviewee D, male, 27 years old

By doing this, I hope to reach a certain level of representativeness but also the coverage of a wide range of travellers who share very different travel routines. As a result, the research outcome will be able to serve as large population as possible.

5.3.2 Usability test

Usability testing is a technique used in user-centered design to evaluate a product which involves representative users conducting representative tasks in representative environments (Lewis, 2006; Lazar et al., 2010). It gives the designers direct inputs on how the real users use the system (Nielsen, 1993). The testing can be conducted on any type of devices varies from desktop or laptop computer, to hand-held devices such a smart phones (Schusteritsch et al., 2007; Lazar et al., 2010). The recent emerge of the *wearable technology* also adds more potential testing devices to the usability tests.

a) Types of usability testing

There are three distinct types of usability testing: expert-based testing, automated testing, and user-based testing. Expert-based testing involves interface experts using structured methods in order to find system flaws; automated testing involves software program using a series of guidelines which are created by experts, to test if the interface meet the guidelines. User-based testing involves representative users performing a series of specified tasks on the interface in order to test the concept and the performance of the interface. User-based tests are the majority focus of usability testing. Expert-based testing and automated testing are also sometimes referred as usability inspection, while usability testing is reserved for user-based testing (Lazar et al., 2010). In this study, the purpose of testing the mobile application is to better understand user's behaviour, routine, preference, and to test the concept/interface of the mobile application in relation to the research problem, rather than improving the interface from experts' perspectives. Therefore, a user-based testing would serve the need for my study.

According to the different phases of the development, usability testing can be either formative testing, summative testing, or validation testing.

Summative testing takes place when there is more or less a formal prototype ready and the goal is to evaluate the effectiveness of specific choices of design. Validation testing take place right before the product is about to release to the public.

Formative testing tends to be exploratory usually takes place in the early phase of the development. It usually tests low-fidelity prototypes and is often informal. There are usually more communication between the researchers and the participants. In this early exploratory phase, the focus is more on how users perceive the interface components rather than how well the users complete certain tasks (Lazar et al., 2010).

The purpose of testing the prototype of the mobile application in this study is to test the design concepts/interface and better understand user behaviour, rather than test how well the mobile application works. Because the design concept coincides with the exploratory of the central problem of this study: *information overload*. Creating mobile application and testing the prototype of it are both the means to get a deeper understanding and further exploration of the problem *information overload* and the possible solutions for it.

b) Stages of usability testing

Usability testing requires advanced planning involves different steps of tasks. Different authors have different opinions on the stages of usability testing (Lazar et al., 2010). One of the suggestions that fits to my study is proposed by Lazar (2006):

1. Choose representative users
2. Choose the test setting
3. Plan the tasks that the participants are going to perform
4. Plan what type of data should be collected
5. Before the test session
6. During the test session
7. Debriefing after the test session

c) Participants of the usability testing

The representativeness of the participants in the target population is essential to the usability test. I will again use the four cluster framework suggested by report “Mobile applications on the way – What do the

travellers want?" (Julsrud et al., 2014) in order to fulfil the requirement for representativeness. Each cluster represents a group of travellers who share very similar travel routine, behaviour, preference and the access to mobile technology. The four clusters together cover a wide range of population which is representative to some extent.

There will be four participants (the same one as the interviewees) from each cluster. The usability test will be followed up by a session of interview where some relevant questions will be asked based on the usability test.

d) Tasks of the usability testing

1. Participants play around with the application and get a bit familiar with it.
2. Participants are asked to find out what is the public transport information concerning Nydalen T-bane station.
3. Participants are asked to adjust their availability to receive information to a certain time that fits them.
4. Participants are asked to make their choice concerning geo location.
5. Participants are asked to make their choice concerning some certain public transport routes.

e) Measurement of the usability testing

The measurements for usability testing can be either quantitative or qualitative, or both. The choice of measurement depends on the purpose of the testing. Common quantitative measurement are task performance, time performance and user satisfaction. In formative usability testing, a very common qualitative measurement is known as "think aloud" protocol. This measurement allows participants to speak out their feelings, frustrations during the test. These information is often very useful feedback and will help for testing the design concept and improving the interface (Lazar et al., 2010).

In this study, the formative usability test is not particularly concerned with the quantitative information such as time of performance, the amount of correctly performed tasks, etc. The study is most concerned with user's qualitative feedback in relation to their feeling and opinions on the design concept/interface. Therefore, the usability testing in this study will be using qualitative measurement with the strategy of "think aloud" protocol. The

researcher will make notes during the test session.

5.3.3 Ethnography

Ethnography, is a qualitative research method which emphasises the detailed observation of people in a natural environment (Randall and Rouncefield, n.d.). In *HCI*, designers get a better understanding into user's world in terms of their needs and interactions with the technology through observations (Lazar et al., 2010). This also supports the idea that IT-use is context-dependent. Context/environment can very much influence users' feelings and behaviours when comes to the use of mobile technology. Even the small details can make a difference such as the weather, the location, the time of the day, the number of people around, etc. Observations may also remedy the loss of relevant information when conducting interviews since the users very often only give the answers which they think are relevant and important and ignore or neglect some of the important details in their own behaviours.

Depending on the specific situation of the ethnography study, researchers can choose their level of participation from *complete observer* (Gold, 1958) to *complete participant* (Gold, 1958). Being more like a observer may involve a greater risk of misinterpretation, and being more like a participant may involve a greater risk of losing perspective (Gold, 1958). In this study, the observation is conducted at a train station. The observation is about to see whether there are people coming to the station without knowing the train is delayed before hand. The observation is very straight forward and involves little risk of misinterpretation. Therefore I chose the role of being a *complete observer* in this ethnography study.

5.3.4 Data collecting process

The data collecting process would be as follows:

- Step 1: Pilot testing of the interview
- Step 2: Conducting interview following Interview Guide A.
- Step 3: Usability test on a mobile application; conducting interview following Interview Guide B.
- Step 4: Conducting ethnography.

Step 2 and 3 are conducted during the same interview with the same

interviewee. They are two phases of the interview.

5.4 Data analysis method

Hosti gives a broad definition for content analysis:

> Any technique for making inferences by objectively and systematically identifying specified characteristics of messages (Holsti, 1969, p. 14)

Content analysis is normally used as in-depth analysis aims at searching for theoretical interpretations that may generate new knowledges. Coding is the technique that is used for analysing text content (Lazar et al., 2010). Coding, according to Corbin and Strauss:

> involves interacting with data (analysis) using techniques such as asking questions about the data, making comparisons between data, and so on, and in doing so, deriving concepts to stand for those data, then developing those concepts in terms of their properties and dimensions. (Strauss and Corbin, 1998, p. 66)

The analysis of the interview data will be mainly based on the written notes made by the researcher during the interview. Because they are easy to work with and they consist of the contents that the researcher is most concerned about. However, it is also possible to go back to the audio recordings if there is anything unclear in the notes which appear to be important for the analysis.

5.5 Reliability and validity of the study

Reliability and validity are the two important criteria concerning the quality of qualitative research (Bryman, 2008). Validity refers to the use of well-established and well-documented procedures to ensure the accuracy of the findings. Reliability refers to the consistency of the results (Creswell, 2009).

Validity can be increased by establishing database consisting of well-organised raw data, which enables tracing back to the analytic result back to the raw data. The use of multiple data source significantly increase

researcher's confidence in interpreting the result, therefore increase validity. While interpreting data, researchers need to keep in mind to not stress the observations that support their pet theory[21] and downplay those alternative results. In another word, researchers should try to avoid their bios as much as possible. By doing so, the validity is also increased (Lazar et al., 2010). In this study, I will audio record and make notes during the interviews. I will also make notes during the usability tests and observation study. All these data is well preserved and possible to be traced back to. While interpreting the data, I will keep in mind to stay objective. If I come across with unsure data in the written note of the interview, I will go back to the audio recording to make sure the accuracy of the data. By doing these, I make sure the validity of this study is relatively high.

Reliability includes two dimensions: stability and reproducibility. Stability refers to whether the same coder code the data the same way throughout the whole coding process. Reproducibility refers to whether different codes would code the same data the same way. It is crucial to develop a set of explicit coding guidance before the coding process, both for achieving reliability from the same coder or multiple coders. Reliability can also be increased by a database because the raw data would be important for the possibility of repeating the research therefore increase the level of consistency (Lazar et al., 2010). In this study, I'm the only coder. I have a set of explicit coding guidance and will follow it during the coding process. The raw data of the study is also well preserved in order to enable the possibility of repeating the research. Therefore, the reliability in this study is also relatively high.

21 Pet theory: the theory that the researchers are in favour of already from the beginning.

Chapter 6. Findings

In this chapter I will present the data findings from the fieldwork with a focus on the themes relevant to the research questions in this study. The data will be presented in the sequence of interview data, usability testing data and observation data. The interview data is divided into five themes: General attitudes about obtaining information and the use of mobile devices; Discussions about several theories, technologies and design concepts; The routine of using public transport; Obtaining information from TV news ticker; and Other relevant information.

6.1 Interview data

The interviews were conducted during the period of June 20, 2015 to July 5, 2015. First I will start with describing each of the interviewees from the aspects I care about in this research. The general description mainly covers their routines of using the public transport and using mobile technologies. According to their routines, each of them belong to one of the clusters to the four cluster framework (Julsrud et al., 2014).

	Interviewee A	**Interviewee B**	**Interviewee C**	**Interviewee D**
Cluster type	the first cluster (“Technology available”)	the third cluster (“Active and social”)	the fourth cluster (“Technology independent”)	the second cluster (“Work and news”)

Personal details	Male, 30 years old	Female, 26 years old	Female, 63 years old	Male, 27 years old
How often uses public transport	3 times/month (averagely)	At least 5 times/week	5 times/week	Everyday
Whether owns car	Drive company car to and back from work. Drive private car for usual private activities.	no	Have a private car.	no
How many Mobile devices one owns	1 smart phone, 1 tablet	2 smart phones, 2 laptops, 1 tablet, 2 ipod, 1 smart watch. Usually use 1 smart phone, 1 laptop, 1 smart watch and sometimes the tablet.	1 smart phone, 1 laptop	1 smart phone, 1 laptop, 1 tablet.
Whether having internet access on the mobile devices	Having internet access on the phone and the tablet all the time.	Having internet access on the phone all the time.	Having internet access on the phone sometime.	Having internet access on the phone all the time.
Routines of using the mobile devices	Having tablet and phone with him at work. Usually use tablet for work-related activities.	Having the phone with her all the time.	Having the phone with her all the time.	Having the laptop and the phone with him almost all the time. During long distance travel, only have the phone with him.

Most usual activities on the smart phone	Phone call, text message, checking time, and facebook. Use facebook mainly for checking news update, interesting articles, pictures, and videos.	Facebook, messengers, several other social applications such as instagram, snapchat, music, phone call, text message (use text message more than phone call because she likes exchanging messages more than chatting on the phone), one game, google, e-mail, checking bank.	Text message and phone call. Very few times google, or read newspaper on the phone. Use e-mail application on the phone to check the number of un-read e-mails (the number shows on top of the application icon on the home screen).	Reading news. Other less often activities include text message, phone call, listening to the news, social network (very little), google (if he does not have the laptop with him), navigation (while walking), e-mail, translation, weather, travel information.

Table 6.1: Description of the interviewees (interview data)

6.1.1 General attitudes about obtaining information and the use of mobile devices

In order to gain a whole picture of the interviewees' general attitude towards obtaining information in the information age and the use of mobile devices nowadays, the questions cover many details in their lives concerning information acquirement and mobile use. All these details can be divided into three categories: the difficulty level of obtaining information nowadays; factors that affect the ability of reading and understanding information; negative influence brought by the mobile use. The relationships between these factors can be seen as follows so far:

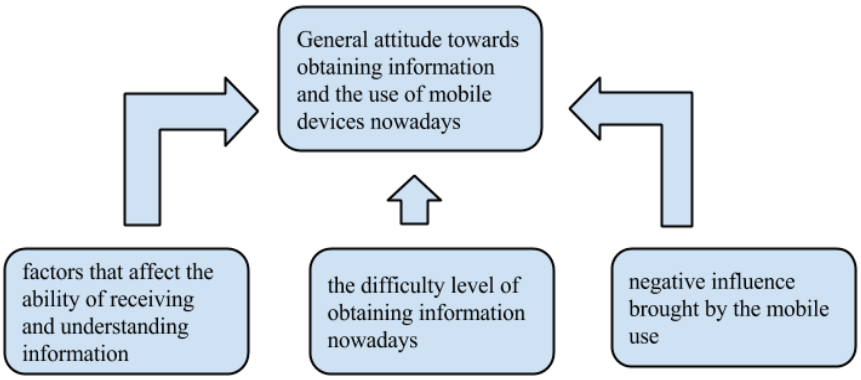

Figure 6.1: Relationship map (1) of the factors within interviewees' general attitudes towards obtaining information and the use of mobile devices nowadays (own illustration)

As shown in the relationship map, the three factors all contribute to interviewees' general attitudes towards obtaining information and the use of mobile devices nowadays. I will first discuss the three lower level factors one by one first, and then move on to describe the general attitude.

a) The difficulty level of obtaining information nowadays

There are a lot of different ways of obtaining information nowadays. You can go for the traditional ways like books, magazines, newspapers, TV, radio, and so on. Or you can go for the newly appeared ways like internet. The questions here are around the issue that whether it is easy or difficult for the interviewees to find the information they are looking for nowadays.

They first all claim that they usually first go to internet to search for the information. There are also the exceptions. For example, interviewee A says that if it's work-related information, sometimes he will go to books first instead of internet.

Then they all indicate that whether difficult to find the information depends on the situations. Three of them (A, C, D) mention it depends on how familiar they are to the information they are looking for. If they know well about what they are looking for, it is easy to find the search word and know where to search. Otherwise, it takes long time to try out different search words to find the best one.

Apart from the similar points, interviewee B says it's usually not a problem for her to find the right search word. For her, what makes a difference is whether the topic she's searching for is popular or not. If the topic is popular then it's easy to find the information. If it's more a personal wondering rather than something popular on the internet, then it is much harder to find the related information. Interviewee D mention that it also depends on his own status. If he's already tired or the time is limited, then searching information on the internet will appear to be more difficult than usual.

Interviewee A also mention that he very often gets distracted or annoyed by many unrelated information in the search result while looking for the information he cares about. This makes his searching more difficult.

b) Factors that affect the ability of receiving and understanding information

All the interviewees claim that if the text information is well-written, it is easier to read and understand. However different interviewees have different opinions on what is well-written. Interviewee A thinks well-written means the information is conveyed clear and short; Interviewee B thinks the words should be put in a right way to be well-written;
Interviewee D thinks the way the words are expressed affect his feeling to the texts, therefore the well-written way should be the way that gives him good feeling.

They all think that if the text information is fun, interesting or important, they read better. In terms of time pressure, three of them (A, B, D) explain that it only makes it worse for them to understand information.

> Interviewee B: Time pressure affect my concentration.
>
> Interviewee D: If I'm reading something, then I will try to read through very fast, but in the end I may not understand much of it.

Only interviewee C think it's not much a problem for her because she's not easily stressed:

> For example, if I'm in the exam, I will get a little

> excited, then I usually read even better than usual.

Some (A and B) prefer the information to be short and clear. They both think the short and clear message help them to concentrate. If it's too much texts, they easily lose concentration.

In terms of the word size, interviewee C prefers the information having a variation of big and small size words. The headline and important information are shown in big size in order to easily catch people's attention. It also helps people to quickly select among topics. Interviewee D says that he usually wouldn't be interested in the information if the words is too small size. He usually adjust the word size on his phone and PC to be bigger.

In terms of the surrounding environment, they have different preferences: Interviewee A prefers silent; interviewee B prefers to be alone; interviewee D prefers to be silent and alone. Interviewee C says it's not a problem if the surrounding is not silent or a lot of people, she can still read and understand well.

> Interviewee C: I like reading. I read every day on bus or subway. Reading on the subway is better than bus, because it's more stable.

c) Negative influence brought by the mobile use

All the interviewees claimed to have been disturbed by their smart phones. The level of intensity of the disturbed feeling is rather different. The ways they are disturbed by the phone are also diverse. I asked them to measure how much they are disturbed by choosing between level 1-10 (10 is the strongest), if they can:

> Interviewee A: I feel I'm sometimes disturbed by the information or notification from the phone....it also depends on the type of information...if it's the information I don't need, like game invitations or advertisements, I got pissed. With those things, I feel level 8-10 disturbed. If it's the information that can be useful for me, I don't mind that much.
>
> Interviewee B: Yes, I'm disturbed. Level 6-7 I guess. When I'm doing something, if it pops up something,

> then I will check...I got notification quite often...then I feel like I'm looking at the phone all the time. I try to ignore it sometimes when I'm doing other things, but very often I will check, then put the phone down.
>
> Interviewee C: Usually ok. Because when I'm at work, or at doctor's, or may be at theatre, I always remember to turn the sound off...I usually only have messages or phone calls...but sometimes, for example, when someone is taking a nap at home and then suddenly my phone rings, I feel anxious.
>
> Interviewee D: I usually turn the sound off, may be have the ones that I'm most concerned sound on. Normally I don't feel disturbed, because I can control the notification. I anyway don't have much notification, phone call or message.

Two of the interviewees (A and B) mentioned that they are annoyed by the pre-install applications on the phone. They both think they don't need most of them. But they need to update them once in a while, and it takes memory space on the phone. Interviewee A says it's a trouble and interviewee B thinks it's irritating. They both think the phone should have less pre-installed applications. They should have the choices of deciding which applications they want to be in the phone.

When comes to the question about their habits of keeping themselves updated with the information from mobile devices and whether it's a pressure, interviewees express different opinions:

> Interviewee A: If it's work related things, then yes I need to keep myself updated, but not much a pressure...I keep my phone on all the time, but it doesn't ring much often. I want my close family to be able to reach me all the time. If it's messages from friends, I only reply when I feel for it. So not a problem.
>
> Interviewee B: Not so often I miss things. I usually have the sound off but I will keep the vibration on. And I check my phone very often...not much pressure.
>
> Interviewee C: I don't check email every day. I like using messages and calls best. I don't need to read message or call back immediately, but once a day at least.

> Interviewee D: Most occasions not. I usually check my phone once a day, that's enough. I usually don't have much emergent thing.

d) General attitude towards obtaining information and the use of mobile devices nowadays

The interviewees are asked to expressed their general opinions about the change the information society and the mobile devices bring them.

First of all, every one recognise the positive things the information society and mobile devices bring them. They all mention they are enjoying the convenience of obtaining information nowadays. Obtaining information is much easier than before.

However, they all claim that sometimes they feel they receive too much information. Although the situations they feel it's too much information differ. Interviewee A and B both think whether they feel it's too much information depends a lot on the type of information, in another word, whether it's the information they need or not. Interviewee A thinks advertisement is the "too much" element to him. Interviewee B says about 10% of the time she feels there's too much information. Interviewee C thinks she's generally getting enough information. Sometimes too much:

> Interviewee C: ...especially when it's sad things, I find me trying to defend myself from all the information. When there's too much information, I just cut myself out. But sometimes information pops out to your eyes when you don't want to see them, like the advertisements in the subway station...you need to know a lot about technology to live a better life nowadays, I feel like I need to learn more of it before I'm getting old...I may need help of technology when I'm old.

Interviewee D feels there's too much information when he's short of time and have to make a decision. If he has the time, he usually doesn't feel it.

About the use of mobile devices, interviewees provide a lot of different points of view. Interviewee C and D think there's no negative thing about the use of mobile devices for them. Interviewee C also gives example:

> When I'm driving alone especially when it's winter, on slippery road, having the phone make me feel safe, I can reach out to people easily, I can check information fast.

Both interviewee A and B mention that using smart phone to get information can be addictive.
Interviewee B describes the situation:

> It depends on self-choice if continue reading or not, but sometimes, I'm curious, I can't stop even I already feel it's too much information. I feel like I have to, even though I feel no I don't need it, but I will still continue.

Apart from the similar point of view, interviewee A thinks there're too much advertisements on the phone which distract him from the real task. It's not user-friendly. Interviewee B thinks the use of phone takes a lot of her time. She very often lose contact with the surrounding. She's not paying attention to people's talking. Therefore she very often would have to ask again what other have said. She thinks the use of mobile devices is more fun than positive. *Things can go a bit slower*, she says.

After the discussion of the three factors and the general attitude. There appear to be new traces of relationships between different actors. Therefore, I re-drew the relationship map. Now it looks like this:

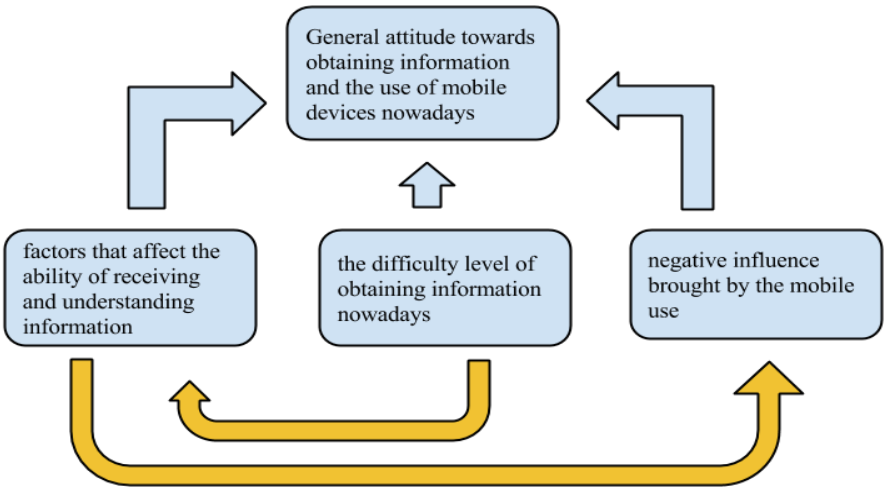

Figure 6.2: Relationship map (2) of the factors within interviewees' general attitudes towards obtaining information and the use of mobile devices nowadays (own illustration)

The new discovered relationships are indicated with the yellow arrows. As we can see, the three lower level factors do not only contribute together to the general attitude, but also interact with each other.

6.1.2 Discussions about several theories, technologies and design concepts

The several mobile technologies that are important for this study are: *presence awareness*, *context-aware computing*, *ubiquitous computing*, and *wearable technology*. Through interviews, I want to find out the four interviewees' attitude towards these technologies and whether they are using them in their daily lives. However, I didn't introduce the concepts to them directly by saying *presence awareness* for example. Based on my own experiences, I assume normal people wouldn't be familiar with these terms. Therefore, I explained the concepts using real-life examples. The interviewees were able to quickly understand the concept and presented their opinions. I will now present the interview results around these four mobile technologies one by one.

a) Presence awareness

The question starts with whether they know or have used the function on their mobile devices which can adjust their availability of receiving *push notification*. Three interviewees (A, C, D) indicate that they are not aware of these functions so far. Interviewee B is using the "don't disturb" mode on her phone every night during sleep. It's a native function of the phone. She explains that she uses it because she wants no *push notifications* during the night. After being told that some applications allow you to adjust your availability for this specific application, she shows very much interests: "Really? That would be so nice! I didn't know that!" She then reached over to her phone and started checking. She then found out that in the "don't disturb" mode, she can choose which applications she wants the *push notifications* off inside of this mode. She can also choose to allow some important phone calls to get through during the "don't disturb" mode.

The discussion then goes to whether they think it's useful for them if the applications have the functions of adjusting user's availability for receiving *push notification*, or if the phone has different modes so users can decide what kind of *push notification* they want in each mode. Three of them (A, C, D) all indicate that they think it would be useful for others, but not so much for themselves.

> Interviewee A: It's a good function. I see the value. But for me, it's not really a problem. My phone doesn't give much notification. But it may be useful for others.
>
> Interviewee C: If I remember to adjust the sound, it's not much problem. I can see it can be useful for some... it may also...can be useful for me, hmmm, but I don't learn new technology that fast.
>
> Interviewee D: It's too complicated...different modes. If I need it on, I will turn it on manually. Or off. Also my time is not stable, I may want it on today for a while but not for tomorrow. Sometimes I want to see it at work, sometimes not.

Interviewee B expresses enthusiasm immediately:

> It will be useful for me!

b) Context-aware computing

All the interviewees have used GPS navigation on their phone one way or another. Interviewee A and C usually use it while driving. Interviewee B and D usually use it while walking. The four of them all affirm that detecting their location for navigation is useful and necessary.

All the interviewees express privacy concern when talking about letting the computing devices know your contexts.

> Interviewee A: If the information is used by criminals, they know for example every one is out on vacation in the family and the house is empty...

Interviewee C thinks the privacy issue is not so much a problem for her, but maybe a problem for some others.

Both Interviewee B and D mention that they notice many applications will ask for their location information. They both usually turn the location detection off for all the applications because they are concerned about privacy.

> Interviewee B: I'm a bit worried about revealing my information. But you can turn it (location detection) off for each app, so it's ok.

> Interviewee D: Sometimes I'm worried. But then I think, I'm nobody. Nobody is going to follow me or anything. I should be safe.

c) Ubiquitous computing

The interviewees are introduced to the concept through the example of "smart house"[22]. All the interviewees show a doubting attitude towards the concept. Three of them (A, B, C) mention that it probably is very useful for people who may need some help in their daily lives such as elder people or disabled people, but not necessary for all. Interviewee B expresses her concern:

22 Smart home, or smart house, is a home that incorporates advanced automation systems to provide the inhabitants with sophisticated monitoring and control over the building's functions. Source: http://smarthomeenergy.co.uk/what-smart-home

> I see how technology changes people. I don't want technology to take over my life, it's scary. People use too much tools instead of doing things themselves. Things can go a bit slower.

Interviewee D has some different concerns: If many people have tested and say it's good, then I may think about it. New technology, the stability is a concern. Privacy is also a concern for smart house. Maybe I will consider when I'm old. When privacy is not as important as my health.

d) Wearable technology

Both interviewee A and B have experiences in using wearable devices. Interviewee A has been using wearable sensors in his work. The sensors can detect oxygen level, gas level, etc, and give warning when the level is dangerous for human body. He describes the wearable sensors as small, no extra burden, easy to use and necessary. Interviewee B has a smart watch which she uses for detecting her activity level. When she's out running, she will combine the smart watch with a sensor which she wears on the chest to detect her heart beat and other measurements. She finds it very useful. On daily basis, the watch will keep track of her activity level and tells her how much calories she has burned today for example. She even feels the wearing the watch starts being a obsession of hers because she's wearing the watch all the time.

When asked about the attitude towards smart watch, three interviewees (A, B, C) indicate the small screen of the watch is hard to read and hard to operate. Interviewee A and C say they wouldn't consider having one now. Interviewee B says she likes having both smart watch and smart phone and synchronize between them. Interviewee D expresses again his distrust towards new technologies. He says he needs to wait until the smart watch becomes popular enough to consider having one himself.

6.1.3 The routine of using public transport

The questions starts with how often each of the interviewees uses public transport. The answers are as follows:

	Interviewee A	Interviewee B	Interviewee C	Interviewee D
How often uses public transport	3 times/month (averagely)	At least 5 times/week	5 times/week	Everyday

Table 6.2: Interviewees' frequency of using public transport (interview data)

The discussion then moves to how they usually obtain the real-time transport information when they are travelling with public transport. Their choices are fairly diverse.

The less often public transport user, interviewee A says he either check before hand on his stationary computer, or just go to the station and check on the digital screen there. He thinks it's easy to find the real-time information on the computer. Interviewee C, who uses public transport every working day also says she usually just walk to the station and check on the timetable there. Because there are quite many choices for her normal route to the work. Only if she will take long-distance transport (bus for example) which comes not that often, or she will take a route she's not familiar with, she will google on the laptop before travelling. Interviewee D, who lives in the city centre and uses public transport every day, says he doesn't check the time for public transport. Because there are many choices at the station. He just need to wait for maximum several minutes for one to come. But he also indicates that when he was living outside of the city centre two years before, there is only one subway line he can take from home. Then he will check the timetable on laptop before hand and then decide when to leave home. Interviewee B is the only one among them who uses transport application very often. She finds it easy to obtain the information she wants. But she also mentions that she finds the most often used public transport application crashes too often.

When asked about their experiences of sudden changes in public transport, every one indicates that they have experienced more than once. Interviewee A and C explain that sudden change doesn't happen to them that often therefore it doesn't concern them that much. To be specific, interviewee A usually uses public transport in non-emergent situations, so that if he goes to the station and finds out there's delay, he would just wait for a bit longer which doesn't bother him. Even though interviewee C takes public transport quite often, but change doesn't happen often to her route. Other than that, she has a lot of choices for lines. If one is delay or changed, she just need to

wait a bit more for the next one. She also mentions that she knows it's a problem for many other people though, because many of her colleagues who are taking other routes have been experiencing sudden change quite often and it becomes a problem for them.

On the other hand, two others (B and D) think the sudden changes have big negative effect on them. Interviewee D tells that when he was living outside of city centre, he experienced delay quite often. Each time that happened, he had to wait at the station for the next one to come, which can takes up to half an hour or more. It's even worse when it's winter and cold. Because the station is outside. Interviewee B says sudden change happen to her sometimes. She finds it annoying. She also mentions that the public transport application sometimes doesn't update fast enough, therefore when there's sudden change in some routes, the application is not giving the correct information. Both of them are aware that the delay information very often can be found on the internet, though both think that nobody has the time to check every time before they are leaving home. Interviewee B also mentions if there is an application that can give a choice for favourite routes of transport and then give information accordingly, would be nice.

6.1.4 Obtaining information from TV news ticker

This discussion relates to the design of the mobile application *Trafficker* (see chapter 4) in this research. It also relates to the usability testing data in the next sections.

All the interviewees have noticed news ticker before (will be referred as "ticker" in the latter part of the thesis). Three of them (A, B, C) express similar attitude towards ticker. They all read it sometimes. If there's anything interesting, they will read more or check somewhere else for more information. They all think the ticker doesn't take their attention away from the TV news. Reading the ticker doesn't affect them watching the TV news either. They also don't feel tired of reading it because they can freely choose themselves to read or not. They all think they are getting a lot useful information from ticker. However, interviewee C thinks that ticker doesn't fit to all the programs:

> For example, I don't think it fits to entertaining program or film. When I'm watching entertaining program or film, I feel I'm relaxed. I don't want more

> information during that. I like news. But not all the time.

On the other hand, interviewee D is not much fond of ticker. He says he normally will only look at the news. If people remind him, he will check the ticker. He says he doesn't feel like getting a lot of useful information from the ticker. Some ticker has advertisement as well. He thinks if the information is important, then it will be shown on the main screen in the news. He also mentions that he doesn't like the scrolling text ticker. He finds it hard to keep up with. The texts are usually gone before he is able to understand.

6.1.5 Other relevant informations

Some information have been repeated or emphasised by the interviewees. It may help to understand the interviewees and the related topics better.
Interviewee A mentions 3 times that he prefers information to be short and clear. As for the format of the information, he prefers drawing than writing. He finds drawing more explanatory than writing in many cases.

Interviewee B emphasises 2 times that while receiving the information, she tends to fall out easily, in another word, it's not that easy for her to concentrate. She also emphasised 2 times that the thing she hates most about an mobile application is that it crushes.

Interviewee C emphasises that sometimes she prefers paper information other than information on the internet. She mentions that she thinks sometimes the paper provide people better interaction. She gives the example of the big paper world map that is attached to the wall of her work place. She says it's very nice that the people who walk by can point out on the map where they are from and explain to other people. It opens a way for people to communicate. Interviewee C also emphasises 3 times that she has a habit of reading every day and she likes it. Therefore she usually read very fast and understand well. She emphasises 2 times that she doesn't learn new technologies fast.

Interviewee D emphasises that mood and time are the most important factors that affect his obtaining and understanding information. He also emphasises 3 times that he's skeptical about new technologies. He will only trust and think about using it after many people have tested. He doesn't like

to be the first ones to try a new technology.

6.2 Usability testing data[23]

I will first summarise several important details about the usability testing.

Type of the test	Formative user-based usability test
Testing object	Interactive prototype of the mobile application *Trafficker* (See chapter 4)
Purpose of the test	Test the design concepts/interface, understand user behaviour, explore the research problem
Participants of the test	Interviewee A, B, C, D
Measurement of the test	Qualitative measurement with the strategy of "think aloud" protocol

Table 6.3: Important details about the usability test

The interviewees were first given a series of tasks (see 4.3.2 Usability test) to perform on *Trafficker*. I didn't give them time limit, because how fast they can accomplish a task is not the concern in this test. The most important thing is that they can get familiar to the functions of *Trafficker* in a relatively normal mood (in order to avoid introducing possible interfering factors such as pressure, nervous status, etc.). After they have played around with *Trafficker* for a while, I started asking some questions.

The question started with the ticker design.

23 NOTE: When presenting the usability testing data, the content in *italic* style is the direct quote from the interviewees.

Figure 4.8: Trafficker on the home screen (screenshot)

All the interviewees like the ticker design and think it's useful for them. However, their opinions slightly differs according to their different needs. Interviewee A really likes the ticker design. He thinks the ticker is giving clear and enough information in a not disturbing way. He also suggests it will be even greater if *Trafficker* also includes information about road condition (such as traffic jam, road maintenance, etc.) for car driving, since he is a frequent user of car. He also suggests *Trafficker* includes map (where user can plan their travelling), weather information, and other information that might affect travelling (both public transport travelling and car driving). Basically, he wants an application that covers the general information he needs for travelling. Interviewee B thinks the ticker is a smart design and really likes it. She thinks it's easy to read and easy to follow when something happened. It won't be in the way all the time when there's no change with public transport. Therefore it's less disturbing than the regular *push notifications*. Interviewee C was skeptical first saying the ticker is not that useful to her, but she can see it's useful for others. But while she continuing playing around with *Trafficker*, she started saying:

> Maybe I can use it too. When there's no change, it doesn't show anything right, and it doesn't distract me, so maybe it's useful for me as well.

Interviewee D, the only one among the four interviewees who says he doesn't like news ticker in the interview session, likes the ticker design on *Trafficker*. He likes it because he's getting what he needs and wants. It will take some of his attention away though since it's on his home screen and he

has a small phone screen.

Then moves to the three functions of choice: “No disturb”, “Geo location” and “Transport type”.

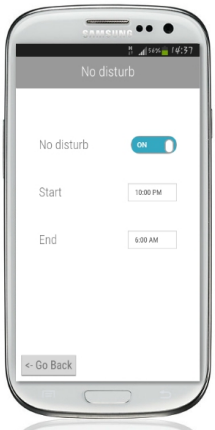

Figure 4.11:
“No disturb” section

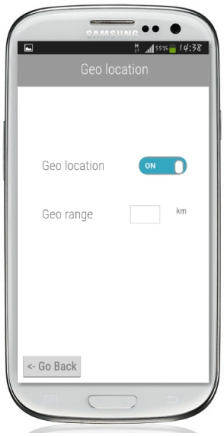

Figure 4.12:
“Geo location” section

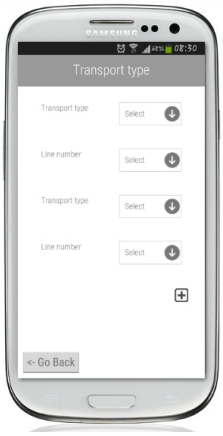

Figure 4.13:
“Transport type” section

(all three figures above are screenshots)

All the interviewees think the “No disturb” function is useful for many people. But only interviewee B is very certain she wants to use it and consider it’s very smart. Interviewee C and D explain that they may use it. Interviewee C explains again that it takes time for her to get familiar to new technologies. Interviewee D thinks he may use during some certain period. Interviewee A on the other hand thinks he doesn’t need this function even though it can be useful for others.

All the interviewees think the “Geo location” and “Transport type” functions are very useful and will use them.

Figure 4.9: More information page (screenshot)

As for other design elements of *Trafficker*, such as font, size, colour, texts length, and so on, interviewees have expressed different concerns. Commonly, they think the size and colour of the text should be outstanding and readable enough. Interviewee A mentions that it's especially important since many may be reading it while walking. Interviewee C mentions that if the text size is too small, she need to use the glasses. But if she needs to use the application on the road, it need to be bigger size for her to read without glasses. She mentions it would be nice to have the option to customise the text size. They all think the ticker information should be short and clear. Interviewee A suggests emphasising the transport type and line number on the ticker information so it would be easier for people to figure out which line it is. They all like normal font style for showing information on *Trafficker*, instead of some cute or weird styles. They all like having the choice of reading more information about the specific transport change. They don't mind the "more information" section is long because they can choose to read or not. Interviewee D however suggests that if the "more information" section is too long, it would be nice to have a small summary on top of the texts.

The usability testing has collected a lot of valuable informations about users' opinions on the design concept and interface of *Trafficker*, as well as users' preferences in mobile application design. These can give implications for further exploration of the research problems.

6.3 Observation data

The observation data is generated by an ethnography study. The basic informations of the ethnography study are as follows:

Date	02/11/15
Location	Platform of the direction to city centre, Haugenstua local train station, Oslo, Norway
Observation time	20 minutes, from 07:50 to 08:10

Table 6.4: Basic details of ethnography study (observation data)

There is only one train line L1 going through this station. I arrived at the station at 07:50. The train was supposed to come at 07:55. As soon as I arrived at the station, I noticed the digital screen at the station shows the time for next train is 08:10. Then came the message from the station broadcast: There is delay with the train, the next train will come at 08:10. 15 minutes later, without any train coming, the digital screen changed and showed the time for the next train is 08:25. I was observing and making notes during the period of 07:50 to 08:10. This is the period when two trains didn't come as planed.

Result of the observation: From the starting time point of the observation, there were 12 people in the station already. During the 20 minutes period, 35 people came to the station. Some went away, some stayed. More people stayed than went away. There are both young and old people among the 35 people. The estimated age range is: 10 – 60. Many showed anxious facial expression while waiting at the station.

The ethnography study observes the users' behaviours from an objective angle. It enables a better understanding about the real-life situation when there's sudden changes with public transport.

Chapter 7. Discussion

In this chapter, I will interpret my findings from the fieldwork (chapter 6), in light of the related theories, technologies and design concepts that were introduced in chapter 3.

The discussion will be around the research questions:

1. The exploration of the phenomenon: information overload
   a). What is *information overload*?
   b). How has the concept developed in recent years?
   c). What are the influential factors to the phenomenon of *information overload*?

2. How to design the mobile application to avoid increasing information overload for the users?

3. How to design the mobile application to cater for travellers' needs in terms of using public transport?

7.1 The phenomenon of information overload

7.1.1 Information overload in user cases

Information overload describes the situation where a person having difficulties understanding the issue or making decisions upon that due to the fact of being exposed to too much information (Toffler, 1984). *Information overload* is not a new phenomenon but people nowadays are still getting to

know it. It can occur to different entities such as human-being, systems, organisations, etc. Many discussions are going on around it. The discussions across the field of psychology, information system, computer science, marketing, organisational studies, sociology, accounting and so on. My research focuses on *personal information overload* in the light of the usage of information system, i.e., mobile applications. *Personal information overload* deals with the issues of how people react, make decisions and solve problems while confronting a large amount of information (Butcher, 1995). Therefore, in this paper, to be more specific, *information overload* refers to the phenomenon that during the usage of mobile applications, when you are trying to deal with more information than you are able to process, you end up with not making the best decisions.

In the information society nowadays, people are enjoying the convenience that the information technologies bring them. All the interviewees will go to the internet first when they want to check some information. Interviewee C, who is 63 and has vivid memories about the situation of obtaining information in the old days, really enjoys the convenience the modern technologies bring her. Other interviewee also express their enjoyment of the modern technologies. There is generally a very positive attitude when talking about the convenience the information technologies bring.

However, people are also suffering from the flood of distracting and unmanageable information coming in the form of instant messages, social network updates, emails, etc (Hemp, 2009). All the interviewees feels that they have been disturbed by their smart phones. Interviewee B, as a very active mobile technology user, check her smart phone very often. Therefore, she doesn't usually miss any message, phone call, or other types of informations. But at the same time, she feels she is quite much disturbed by the phone (she described as 6-7 level disturbed if measure from level 1 to 10, 10 means the highest). According to her, she gets *push notifications* quite often and she would check when they come. Therefore, she feels she's looking at the phone all the time. She tries to ignore them when she's busy with some other things, but many times she can't help checking the phone. She also mentioned that she very often lose the contact with people around her because of her attention on the phone. She misses what people said in reality therefore need to ask them to repeat. In a way, by obtaining information from the phone, she misses information from the reality.

People are also required to process an increasing amount of information at

each moment. Some are relevant, some are irrelevant; some are emergent, some are unnecessary (Eriksen, 2001). According to interviewee A, he finds many unnecessary and irrelevant information pops up when he's trying to search something on internet. Moreover, there is one big disturbing factor when he's using information technologies: commercials. He finds them annoying and distract him from the real tasks. The popping out action is a way of forcing people to process the information.

Several interviewees mentioned the word *addictive* when they are talking about their usage of information technologies. Interviewee A describes the situation of using mobile devices at work as: It's fun and you can share things with colleagues. But it's also addictive. Interviewee B and D both mention that sometimes when there are too much information about one news topic for example, they found themselves keeping on looking at more and more information, even though they already feel it's too much information that they should stop, but they find it very often hard to stop. Interviewee C also mentioned that sometimes she finds she's defending herself from all the information showing on TV or internet, especially when it's sad news. It shows that the easy access to information and the vast amount of information can potentially create a type of addiction which make people want to get to know more which is beyond their ability of processing.

Hemp (2009) mentioned that nowadays, people dare not ignore the information that is not directly addressed to themselves. More over, people end up generating the stress of wanting to deal with every single information they receive but simply are not able to process every single one of them. People become overwhelmed and stressed. However, all four interviewees in this research don't feel much pressure of keeping themselves updated all the time in case they miss information. Three of them, who are not very active users of mobile technologies, don't feel the need to keep themselves updated all the time, nor they are afraid of ignoring informations. They all feel as long as they have control over the phone, for example turning the alert for *push notification* on for the important things, they don't have any pressure of keeping themselves alert all the time. They don't have that much *push notifications* and they usually check the phone at least once a day. They only reply when they feel like to. On the other hand, interviewee B, who is a very active user of mobile technologies and has many different applications on the phone include social networks, game, messengers, etc, doesn't feel the pressure of keeping herself updated all the

time either. She usually turn the sound off but keeps the vibration on, which is another way of controlling the use of phone. She checks the phone very often. Even though she gets a lot of *push notifications* all the time but she doesn't miss any. It's not a pressure because it's more a habit for her. Therefore, how much people can control the technology and how smoothly the technology can integrate to people's lives, makes a difference in whether people feels the stress.

Information overload is proven to be existing in the cases of the four interviewees. They all enjoy the advantages that information technologies bring them. But at the same time, they all recognise the fact that they are disturbed by the informations sometimes. The most active user appears to be the one that is disturbed most. For the less active users, who don't receive *push notifications* very often, how much they feel disturbed depends a lot on the type of the information. If it's irrelevant information, the disturbing level can be even higher than the most active user. If it's relevant information, they don't mind that much.

There is a feeling of addiction in obtaining information technologies, both with active user and the less active users. This addictive feeling is very possibly caused by the easy access of information and the vast amount of information nowadays. The addiction make them want to continue process more information even though they already feel overloaded with information.

Whether they have control over the use of information technologies also plays an important role in their feeling of pressure in keeping themselves updated all the time with all the information, whether directly addressed to them or not. The three less active users of information technologies feel that as long as they have control over the phone to allow the most important thing give *push notification*, they don't feel the pressure of keeping themselves alert. They check the information at their own pace. The very active user in this case however feel that as long as it becomes more or less a habit to check the phone, she doesn't miss any information or feel the pressure of keeping herself alert all the time.

7.1.2 Influential factors for information overload

Ho and Tang (2001) investigated five industry cases and concluded three influential factors to the phenomenon of *information overload*:

- *Information Quantity*
- *Information Format*
- *Information Quality*

Based on others' work of *information overload*, Jackson and Farzaneh (2012) derived some key definitions, situations and fundamental components and came up with a model. The model describes the contributing factors for the phenomenon of *information overload* and how they are contributing to the phenomenon. Seven units of contributing factors are described:
Unit 1: *Quantity of Information*, refers to the the available information that is accessible for the individuals;
Unit 2: *Characteristics of Information*, refers to level of complexity, ambiguity, novelty, intensity and uncertainty associate with the information;
Unit 3: *Quality of Information*, refers to how well the information meets the need of the users, i.e., information usefulness. It's assembled by two factors relevance and validity;
Unit 4: *Information Processing Capacity*, refers to the phenomena that, due to the limitation of human brain that has been scientifically proved, people can only process a certain amount of information at the same time;
Unit 5: *Available Time*, refers to the amount of time for task performance;
Unit 6: *Task and the Process Parameters* are made up of multiple factors combining task novelty, task complexity, multi-tasking and task interruption;
Unit 7: *Personal Factors* are made up of multiple factors combining level of prior experiences, personal skills, cognitive style, motivation of the person, and personal situation.

Other than the factors assembling the model, there is also one more factor *Sources of Information* that was mentioned by the authors. *Sources of Information* refers to the variety of information sources that are available for people. Some are *pushed information* which people have little control over, some are *pulled information* which people have greater control over (Jackson and Farzaneh, 2012).

Different factors are not entirely independent from each other:
- *Characteristics of Information* has a relationship with *Information Processing Capacity* and *Personal Factors*;
- *Quality of Information* has a relationship with *Quantity of Information*, and also associates with *Information Processing Capacity* and

Available Time;
- *Information Processing Capacity* can't be separated from *Personal Factors*;
- *Task and the Process Parameters* associates with *Information Processing Capacity*;
- *Sources of Information* can influence all the other factors (Jackson and Farzaneh, 2012).

Based on the theories above, I investigated the contributing factors for *information overload* in users' cases during the interviews. Part of the result is shown in the table below. "+" means the factor increases the chance of *information overload*,; "-" means the factor decreases the chance of *information overload*. "0" means no effect. "+-" means the factor can either increase or decrease the chance of *information overload*, whether increase or decrease depends on the specific elements of the factor.

	Interviewee A	Interviewee B	Interviewee C	Interviewee D
Quantity of Information	+	+	+	+
Characteristics of Information (includes format of information)	+ -	+ -	+ -	+ -
Quality of Information	-	-	-	-
Available Time	-	-	0	-
Task and the Process Parameters	+ -	+ -	+ -	+ -
Personal Factors	+ -	+ -	+ -	+ -
Sources of Information	+ -	+ -	+ -	+ -

Table 7.1: Contributing factors to information overload (interview data)

All the contributing factors have been mentioned by most interviewees

based on their own experiences:

- *Quantity of Information*: All the interviewees mentioned that they have easy access to a lot of information through the internet nowadays. However they all feel that sometimes there is too much information available, as a result they feel overwhelmed. Even if it's the information they care about. Interviewee B and C both mentioned that sometimes there are too much information about one topic they particularly care about, they found themselves not able to stop absorbing more information even though they already feel they've received too much information. Interviewee B refers it as an obsession. Interviewee C describes the situation as she's trying to shield herself from all the information.

- *Characteristics of Information*: Based on the interview data, *characteristics of information* here means more than just complexity, ambiguity, uncertainty and novelty of information as Jackson and Farzaneh (2012) concluded. It also includes format of information, and some other details about the information. Three interviewees mentioned that when they are trying to search for some information online, how difficult and overwhelming is it to find the information they want very often depends on how familiar they are to the information. If they are familiar to the information they are looking for, it's easy for them to find a proper search word. If not, it takes time to try out different search word and read through a lot of information before they may be able to find the information they want. Interviewee B thinks it also depends on how popular the topic is. It takes much more effort to find the information if it's something less popular on the internet. They all think if the information is fun and interesting, they understand better. Three of them think if the text information is well-written, it helps them to understand. Both interviewee A and B think short and clear information helps them to concentrate. If the texts are too long or too ambiguous, they easily lose concentration. The size of the words also matters. Interviewee C prefers the information have a variation of big and small size words between title, summary and content. For example, she would like to be able to quickly select the content she's interested in when reading a newspaper without reading too much texts. Interviewee D says that he usually wouldn’t be interested in the information if the words is too small size. Therefore, he usually will adjust the word size to bigger when he's reading on mobile phone or laptop. In terms of the format of information, interviewee A mentioned that he usually prefer drawing than texts when trying to understand something.

- *Quality of Information*: All the interviewee think that whether the information is needed or important matters. Interviewee A mentioned that he very often gets distracted and annoyed by many unrelated information such as advertisements when he's searching for some information on the internet. Sometimes, the advertisements are integrated into an article, therefore he is forced to look at the advertisements while reading the article. Both interviewee A and B dislike the fact that there are a lot of pre-installed applications on their smart phone. They don't need most of them. Meanwhile, they have to update those applications once in a while. Interviewee D thinks validity of the information matters a lot to him. When he's searching for information, he has the habit to go through a lot of information until he finds the source that he trusts.

- *Available Time*: Three interviewees have told that time pressure only worsens their task performance. They usually will go through the information very quickly due to the time pressure, but very often without really understanding the information. However, interviewee C thinks time pressure is not necessarily a negative thing for her. Sometimes, for example in an exam, the excitement that is partly caused by the time pressure makes her perform even better than usual. The precondition here is: *Available Time* is around a reasonable amount, which is possible for finishing the tasks.

- *Task and the Process Parameters*: Three interviewees mentioned that surrounding environment sometimes affects their understanding of information, especially in terms of reading. Interviewee A prefers to have a silent surrounding; interviewee B prefers to be alone; interviewee D prefers to be silent and alone. Interviewee B thinks it's hard to operate on the smart phone while walking even though she does it half of the time while walking. Other interviewee prefers not to use phone while walking because they think it can be difficult. Interviewee C emphasised two times during the interview that she doesn't learn new technologies fast, therefore, introducing a new technology to her can be overwhelming sometimes.

- *Sources of Information*: All the interviewee mentioned that whether they have control over the information matters. Three less active mobile technologies users feel they are usually not disturbed by the *push notifications* from the devices. The main reasons are that they usually only reply or check the information when they are available or feel like to. They have full control over whether obtain the information or not. When they

have little control over whether obtain the information or not, such as the commercial in the subway station or the commercial that pops up when browsing internet, they very often feel distracted and overwhelmed.

- *Personal Factors*: Interviewee D thinks whether it's tiring and overwhelming when searching or receiving information depends a lot on his status. If he's tired already or in a bad mood, he feels more overwhelming when obtaining more information. Three interviewees mentioned the addictive factor when they are obtaining information. They feel like obtaining more information even though they already feel overwhelmed. While the other three interviewees feel disturbed by the environment when reading, interviewee C can read anywhere. According to her, she likes reading and she reads everyday. Therefore reading for her is very easy and natural. Moreover, interviewees' answers around all the other factors show that, one factor can be very influential on one person but unimportant to another. *Personal Factors* are the important factors here to make the difference.

Information Processing Capacity was not measured in this study due to the difficulty of the measurement.

Among all the contributing factors, *Quality of Information*, *Sources of Information* and *Personal Factors* appear to be the three more influential factors. The same point of view about *Quality of Information* and *Sources of Information* have been repeatedly mentioned by several interviewees and also been emphasised by some interviewees as very important. *Personal Factors* appear to be the factor that influences all the other factors. Therefore, I conclude these three factors as the more influential factors in this study and the other four as normal factors. All the factors contribute to the phenomenon of *information overload*.

Based on the discoveries from the interview study, I drew a relationship map illustrating the relationships between different factors and how they are contributing to the problem of *information overload*.

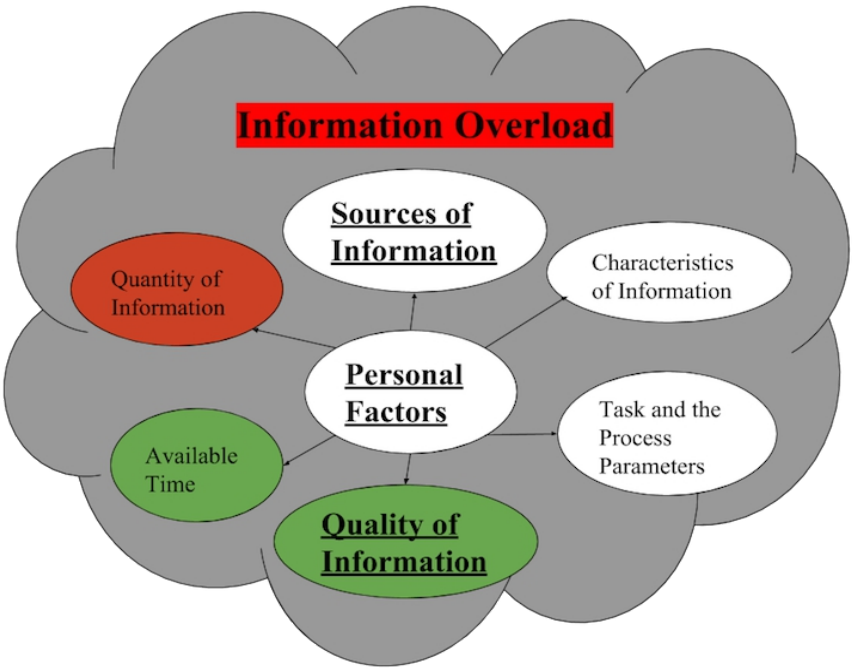

Figure 7.1: Relationship map of the influential factors for information overload (own illustration)

Inside of the "cloud" of the problem *information overload*, there are seven influential factors that are discovered in this study. The three factors in the middle are the more influential factors. Whether the users have control over the information and whether the information is needed by the users, are the two very important factors that have been mentioned or emphasised by the interviewees repeatedly. These two factors refer to *Sources of Information* and *Quality of Information*. *Personal Factors* influence every other factors. Depend on every individual interviewee's various of *Personal Factors*, the factor that influences others may not influences him/her, the factor that is trivial to others may appears to be very influential to him/her. This is illustrated by the arrows. The factor that is coloured red is the factor that increases the chance of *information overload*; the factors that are coloured green are the factors that decrease the chance of *information overload*; the factors with no background colour are the ones that can either increase or decrease the chance of *information overload*.

7.2 Design to avoid information overload

Several information technologies have been mentioned by others' work as the potential solution for the problem of *information overload*. They are *presence awareness*, *context-aware computing*, *ubiquitous computing*, and *wearable technology*.

Based on these theories and technologies, and inspired by Android Wear's concept *glanceability* (“Android Wear,” 2015), a mobile application *Trafficker* is designed to further test the theories, technologies, and the *glancebility* design concept. *Trafficker* borrows idea from the TV news ticker and aims at updating the users with public transport information *at a glance*. In another word, the application requires as minimum attention from the users as possible to potentially reduce the chance of *information overload*.

I will first discuss these theories, technologies and design concepts in the user cases. Then I will do a concluding discussion around the question of how to design to avoid *information overload*, combining the relationship map of the influential factors for *information overload* that I drew earlier and the discussions about the theories, technologies and design concepts.

7.2.1 Presence awareness

Presence awareness refers to users' level of availability for receiving information on mobile devices in this study. *Presence awareness* helps the users to organise their availability in terms of when to receive information. This avoids information coming at a un-welcoming time for the users. Therefore, it helps to lower the possibility of *information overload* (Spira, 2011).

All the interviewees think keeping their *presence awareness* up-to-date to the mobile devices is useful in terms of getting less disturbed. The three less active mobile technology users think keeping *presence awareness* up-to-date is very useful for many other people, but may not be that useful for themselves. There are two reasons for that: first, they usually don't receive that much *push notifications*; second, they all have their own plans regarding when they want to check or reply the information, therefore they normally don't feel disturbed by the mobile devices. Interviewee D also

mentioned that he thinks it's too complicated if you need to set different modes for the availability of receiving *push notification*. He prefers to do it manually when he feels like to. Interviewee C was a bit hesitated whether it's useful for herself. She emphasised that she doesn't learn new technologies that fast. However, during the usability test for the mobile application *Trafficker*, interviewee C and D became more interested in the function of "No disturb" which user can adjust their presence information with. They think it's not only useful, but also easy to use and easy to understand. They both indicated that they want to use the function.

Interviewee B, as the most active mobile technology user in this study, has experienced the advantage of keep *presence awareness* up-to-date to her phone. However, the function she's using is rather simple and limited. During the interview, she's very interested in the technology after being introduced to it. During the usability testing, she expressed again her enthusiasm about the function and is very certain that this is very useful for her.

All the interviewees see the value of keeping *presence awareness* up-to-date on their mobile devices. Whether they think it's useful for themselves depends on many *Personal Factors*, such as their active level of using mobile technologies, their former experience of using mobile technologies, etc.

7.2.2 Context-aware computing

Context-aware computing is the idea that mobile devices or mobile applications provide different services when the users are in different contexts. The contexts usually strongly relate to users' location (Schmidt, 2014) and activity (Schmidt et al., 1999). Context can also include a broader range of factors which can be divided into two groups: human factors and physical environment (Schmidt et al., 1999).

Context-aware computing meets users' need better regarding providing appropriate information in the appropriate context. It saves users' trouble of processing unnecessary information in a certain context which have the potential to decrease the risk of *information overload*.

All the interviewees have used GPS navigation on their phone one way or another. They all think that detecting location for navigation is useful and

necessary. It saves them a lot of trouble. However, all of them expressed worries regarding revealing their private information such as location and so on to other people through mobile devices. They don't want their private information to be misused. Therefore interviewee B and D usually turn the location detection off for most applications on their phones. Interviewee D mentioned that he tends to trust the application more if the provider company has credibility on the market. During the usability test, all the interviewees like the function of "Geo location" on *Trafficker* and think it's useful for themselves.

The general feedback about *context-aware computing* regarding location detection is positive. The technology has the potential to reduce the chance of *information overload*. However, uses have worries around privacy issues.

7.2.3 Ubiquitous computing

Ubiquitous computing refers to the phenomenon of information technology nowadays allowing us to step away from the stationery computer and freely enjoy the computing technology on any of the devices (smart phone, tablet, laptop, etc) at any of the locations (home, office, beach, mountain, etc) (Ling, 2014). Some believes that ubiquitous computers will help overcome *information overload*, people can obtain more information while taking a walk in the woods for example (Weiser, 1991), therefore, people can get the information while relaxing and taking a walk, instead of sitting in front of computer and feeling frustrated.

Interviewees are introduced to the concept through the example of "smart house". All the interviewees show a doubting attitude towards the concept. Most of them think it will be useful for people who may need help on a daily basis such as elders and disable people, but not necessary for all. They expressed a lot worries such as privacy issue, stability, too much technologies taking over people's live, etc.

The feedback on *ubiquitous computing* is generally sceptical. Instead of seeing the value, people expressed more worries.

7.2.4 Wearable technology

Wearable technology refers to the technology that enables the integration of computer or electronic technologies and the items people can wear on their

body in daily life, such as clothing or accessories. These wearable devices can perform the same tasks as computers can do. Whether invasive or not, the ultimate goal of the wearable devices is to provide the users seamless, hands-free, convenient and portable experience of accessing electronic or computer technologies. The experience of smoothly incorporate the usage of technology and people's daily lives (Tehrani and Andrew, 2014). Android Wear's concept *glanceability* is an representative of one of the goals *wearable technology* want to achieve. People can get update information just *at a glance* with minimum effort ("Android Wear," 2015). This certainly has the potential of battling with *information overload*.

The two interviewees who have experienced using wearable devices have very positive feedback. They enjoy the convenience of it. Most interviewees think the screen of the smart watch is too small therefore inconvenient to operate. Hence, how the concept *glanceability* ("Android Wear," 2015) that is brought by Android Wear is working in reality worth further investigation. Something worth notice here is that both interviewee C and D are the two people who explicitly mentioned that they don't like reading small texts. This can be an important contributor to their attitude towards smart watch.

7.2.5 Ticker concept

Inspired by Android Wear's concept *glanceability* ("Android Wear," 2015), I came up with the idea of having ticker function in a mobile application to update public transport information. The ticker idea is originated from TV news ticker. Unlike the most common *push notification*, the ticker will update users the information *at a glance.* Due to the nature of ticker, users don't need to pay much active attention while getting the information. Therefore the ticker design can potentially reduce the chance of *information overload*.

The investigation about the ticker concept started with questions about TV news ticker. Three interviewees have very positive attitudes towards TV news ticker. They all read it sometimes if they notice something interesting. They feel they are getting a lot of useful information from it. They all think that reading ticker doesn't make them tired or take too much of their attention from the TV news. On the other hand, interviewee D is not fond of TV news ticker. He usually finds not too much useful information there. He mentioned that some ticker has advertisements too which is annoying.

Moreover, he doesn't like the scrolling text ticker. Very often he's not able to read fast enough before the information disappears.

During the usability test, all the interviewees tried *Trafficker* and were asked about their opinions about the ticker design. They all like the ticker design and think it's useful for themselves, including interviewee D who said that he doesn't like TV news ticker. Interviewee A thinks the ticker gives clear and enough information in a non-disturbing way. Interviewee B thinks it's easy to read and easy to follow when something happened. Moreover, it won't be in the way all the time when there's no change with the public transport. Therefore it's less disturbing than the regular *push notifications*. Interviewee C thinks the ticker won't distract her since it won't show any information if there's no change in transport. Interviewee D likes the ticker design because he gets the information he needs and wants.

The general attitude towards the ticker design on the mobile application is very positive. It fulfils the purpose of giving users updated information *at a glance*. It apparently has a big potential of reducing the chance of *information overload*.

7.2.6 Design to avoid information overload

Based on the study of several technologies, theories and design concepts above, and the relationship map of influential factors for *information overload* I made, some implications can be drawn regarding the research question: how to design mobile applications to avoid *information overload*.

The two key points for reducing the chance of *information overload* is giving users the possibility to control the way they are receiving information, and giving users the information they want. These two points relate to two factors which influence *information overload*: *Sources of Information* and *Quality of Information*.

As mentioned before (in chapter 3), there are normally two types of *Sources of Information* an individual receives from, either *pulled information* or *pushed information* (Jackson and Farzaneh, 2012). *Pushed information* in mobile technology context, can also be referred as *push notification*, which is the delivery of information from a software application to a mobile device without a specific request from the user (Rouse, n.d.). *Push notification* is widely used by mobile applications nowadays. However,

push notification usually requires a lot of active attentions from the users and is often referred as disturbing. The concept of ticker, a special form of *push notification*, proved to be much less disturbing than normal *push notification* (which usually pops up on the screen with sound or other types of alerts). The ticker is able to update users with information *at a glance.* Users only need to pay very little amount of active attention to get the information they want.

Using ticker to send special form of *push notification* is one way to reduce the chance of *information overload* from *Sources of Information*.

Another way is to give users more control over the sources they receive information from by keeping *presence awareness* up-to-date to mobile applications. To realise this, mobile application can give users the choice of indicating when they are available to receive information and send information to the users according to their availability. It is tempting to make this function detailed and complicated to have a full picture of user's presence information. For example, synchronize the application with user's calendar to get user's schedule information. However, it is a thin line between being useful and too complicated for the users. Complicated functions may increase the chance of *information overload*.

Context-aware computing increases *Quality of Information* and helps to avoid *information overload*. By knowing user's context, mobile applications filter informations to send to the users the informations that are most relevant. It saves users the efforts of going through a lot of irrelevant information which is one of the main reasons of users feeling disturbed. In the mean time, mobile applications should give user the choice of turning off the context detecting function, such as location detection. Some users are concerned about their private information and may not want to give away their context information to the applications.

Mobile application *Trafficker* gives users the choice to keep *presence awareness* up-to-date by giving them the choice of adjusting their available time period of receiving information (“No disturb” section). It is suggested by the users that the time period of choice can be more detailed. Instead of having only one time period of choice, the application should give several time periods of choice. In this way, users can divide their available time into several periods, which is more common in reality.

In “Geo location” and “Transport type” sections of *Trafficker*, user can choose to update their context informations to the application. In this way, the application filters the information and only shows updated information when there's change to the transport routes that users concern about.

Based on the discovery of this study, *Trafficker* serves well the purpose of sending users the updated public transport information without increasing the chance of *information overload*.

7.3 Design to cater for travellers' needs

It has been discovered by report “Mobile applications on the way – What do the travellers want?” (Julsrud et al., 2014) and the fieldwork in this study that, getting updated public transport information is one major need of travellers. Apart from that, users also have other needs regarding using mobile applications during the public transport travel, which have been discovered by the study. The mobile application design should also take these needs into consideration.

7.3.1 The need of getting updated information

Both the interview and the ethnography study indicate that, not getting updated information in time when there's sudden change with public transport is a problem for many people of different ages. It costs people time, energy and affect people's plans. Especially when the weather condition is unpleasant, experiencing sudden change with public transport without knowing before hand is even more irritating.

According to the data I collected in “A review of the mobile applications for public transport” (Julsrud et al., 2014), there are many different mobile applications providing the public transport information. Many of them are widely used by travellers. Some of them provide updated information when there's sudden change with public transport. However, both interviewee B and D mentioned that, even though they are active users of public transport mobile applications, they don't have the time or habit to check the applications to see if there's sudden change with their daily routes every time before leaving. Therefore they end up not getting the information even though the information is available on the mobile applications or internet. Interviewee B said (before being introduced to *Trafficker*) that if there's a mobile application that can show the change information with her favourite

route and give *push notifications* accordingly, would be very nice.

Mobile application *Trafficker* successfully serves the purpose of sending users the updated information. At the same time, it saves users the trouble of actively checking the updated information every time before travel.

7.3.2 Privacy concern

The popularity of the mobile technologies also bring the concern of security for one's privacy. Mobile devices can contain essential information of the users. By using mobile devices, users are under the risk of exposing these informations (Migrator, 2000). Several interviewees have expressed their worries about privacy issues. How to protect user's private data is an important issue to be taken into account when designing mobile applications. Giving users the choice of turning off context detecting function (such as location detection) on the application is one way to lower the risk of users revealing their concerned information.

7.3.3 User experience and Usability

Based on the comments in the application stores, two main complaints towards the public transport mobile applications are about *user experience* and *usability*. The complaints include ugly design, function is too difficult to use, crashes too often, loses stored data. Many users mention the word *user experience* and *usability* specifically (Julsrud et al., 2014). This study also revealed users' concerns about these two issues.

Interviewee B thinks crushing is the most annoying thing about mobile applications. She also mentioned that the public transport mobile application she's using now does not update fast enough sometimes therefore end up showing wrong information. All the interviewees are very concerned about whether the mobile applications are simple to use. Interviewee C doesn't learn new technologies that fast. Interviewee A prefers information to be short and clear. Interviewee D is scared of complicated functions and would rather choose not to use. Interviewee B as an active user of mobile technologies turns out not be familiar with the application she uses very often. It implies that the complexity of the mobile application may scare people away from enjoying the functions.

About the design of *Trafficker*, users mentioned some details: The size and

colour of the text should be outstanding and readable enough, and the ticker message should be short and clear. It is especially important for a public transport application because many users may use it during walking.

7.3.4 Universal design

Universal design aims at designing the product so that it can be used by the widest range of people as possible ("What is Universal Design?," n.d.). The selection of interviewees are based on four types of people who have different needs, preferences and routines in terms of using mobile applications (Julsrud et al., 2014). This is an effort to design for serving a wider range of people. However, due to the limitation of time and scope of this study. The coverage of users in this study is rather limited. However, the data collection from the four different type of users did give some implications for the *universal design* concept. For example, interviewee C, who is 63 years old mentioned that she prefer the text size to be big enough on *Trafficker* for her to read without glasses. Since it's not that convenient to use the glasses while walking. Different interviewees showed very different choices and preferences about the same issue based on their own routine and experience. *Universal design* is one element that the designer should always bear in mind.

7.3.5 Design to cater for travellers' needs

A mobile application like *Trafficker* serves well the purpose of updating users with public transport information. Besides that, there are several other design considerations that need to be taken into account when designing a public transport mobile application:

- Privacy concern: Applications should have control over the user information it gathers and does not misuse it. The users should also be given the choice of how much information they want to give to the application.
- Stability of the application: Application should try to avoid crushing and other stability issues.
- Simplicity of the design and function: Applications should be easy to use. Every function of the application should be simple to understand even for the new users.
- Readability of the information: The information on the application should be easy to read, easy to understand even when the users are walking

or occupied by other tasks at the same time.

- Universal design: Applications should be designed for as big group of travellers as possible. Based on people's different needs, designers may consider giving users more options for customizing the application.

Chapter 8. Conclusion

This chapter concludes the thesis and indicates the possibilities for future work.

8.1 Summary of the study

a) The first question is to explore the phenomenon of information overload and try to understand:

- **What is information overload?**
- **How has the concept developed in recent years?**
- **What are the influential factors to the phenomenon of information overload?**

The study shows, while enjoying the convenience of obtaining information through mobile technologies, users also suffer from *information overload* to different extent. *Information overload* in this study, is the phenomenon while using mobile devices, people sometimes try to deal with more information than they are able to process, they end up not making the best decisions.

Information overload is a phenomenon across different disciplines. Over the years, researchers from different disciplines have been giving *information overload* different understandings and explanations based on their fields which vary from psychology, information system, computer science, marketing, to organisational studies, sociology, accounting and so on. Nowadays, with the help of information technology, people are having

much easier access to much larger amount of information. Information is available at a simple click or a swipe. In the mean time, *Information overload* has become an increasing problem.

It is important to have knowledges about the factors that affect *information overload* before thinking about solutions to the problem. Based on the findings in this study, I drew a relationship map of influential factors for the phenomenon of *information overload*:

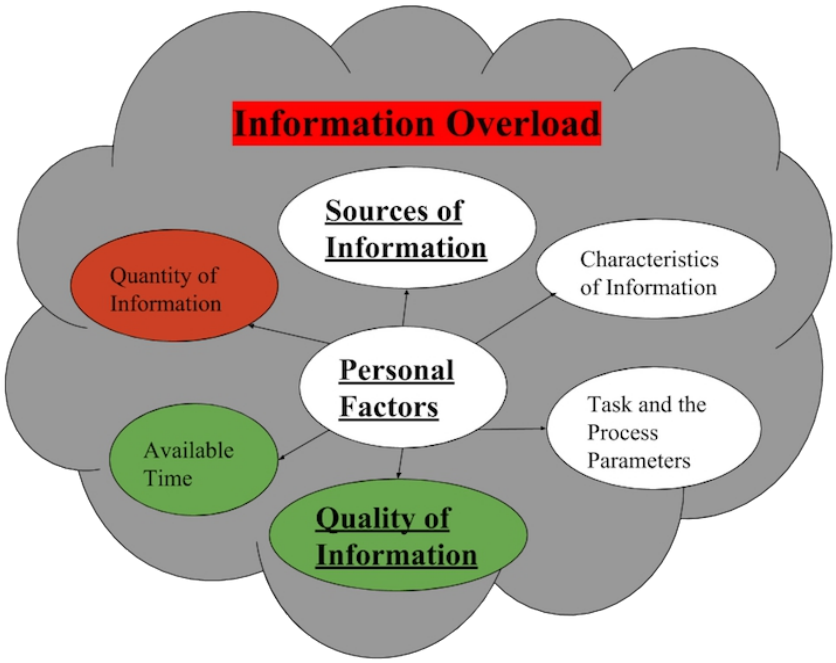

Figure 7.1: Relationship map of the influential factors for information overload (own illustration)

Sources of Information refers to the variety of information sources that are available for people. Some are *pushed information* which people have little control over, some are *pulled information* which people have greater control over. *Personal Factors* are made up of multiple factors combining level of prior experiences, personal skills, cognitive style, motivation of the person, and personal situation. *Quality of Information* refers to how well the information meets the need of the users, which is assembled by two factors relevance and validity. *Quantity of Information* refers to the amount of the available information that is accessible for the individuals. *Available Time*

refers to the amount of time for task performance. *Characteristics of Information* refers to level of complexity, ambiguity, novelty, intensity and uncertainty associate with the information. *Task and the Process Parameters* are made up of multiple factors combining task novelty, task complexity, multi-tasking and task interruption.

Inside of the "cloud" of the problem *information overload*:

- Seven factors are discovered by this study as influential factors;
- The three factors in the middle of the map: *Sources of Information, Personal Factors,* and *Quality of Information*, are the most influential factors;
- *Personal Factors* influence every other factor (indicated by arrows);
- The factor that is coloured red: *Quantity of Information*, is the factor that increases the chance of *information overload*;
- The factors that are coloured green: *Quality of Information* and *Available Time*, are the factors that decrease the chance of *information overload*;
- The factors with no background colour: *Sources of Information, Personal Factors, Characteristics of Information,* and *Task and the Process Parameters*, are the ones that can either increase or decrease the chance of *information overload*.

There are also some other interesting discoveries in this study regarding the phenomenon of *information overload*:

- The demand for obtaining more information can be addictive. Users sometimes find themselves in the situation that, they already feel they've got enough information and start feeling overwhelming, but they they still can't stop themselves from getting more information since the information is available and so easy to get. The easy access to information may potentially create a type of addiction which make people want to get more information which is beyond their ability of processing.
- In contrast to Hemp's study (2009), the users in this study don't necessarily feel the stress of keeping themselves updated all the time in case they miss information, no matter they are very active users or not very active users of mobile devices. They have different strategies of dealing with the incoming information. Some checks and deals with the information whenever it comes, however it's more a habit than stress. Some doesn't feel the need of keeping themselves updated all the time, therefore only checks or deals with the information when one feels like to. It suggests that, how

much people can control the technology, and how smoothly the technology integrates to people's lives, make a difference in people's feeling level of *information overload*.

b) The second question is how to design to avoid information overload.

To answer this question, I investigated several theories, technologies and design concept, both theoretically and in user cases. I also designed a mobile application *Trafficker* inspired by the theories, technologies and design concept that I studied in chapter 3. *Trafficker* is used for updating travellers with public transport information. Usability testing has been conducted in this study around the design concept of *Trafficker*.

The study gives some design implications for avoiding *information overload*:
Sources of Information and *Quality of Information* are the two most influential factors to the phenomenon of *information overload* that designers can work on. The key points here are to give users the choice of controlling the way they are receiving information, and give users the exact information they want.

Sources of Information are usually two types: *pulled information* and *pushed information* (*push notification*). *Push notification* is commonly used by mobile applications however proved to be disturbing in many cases. The ticker design in *Trafficker* is a special form of *push notification*. It borrowed the idea from TV news ticker and is able to update users with information *at a glance*. This way of sending information reduces users' active attention and is proved to be less disturbing than normal *push notification*. In another word, it reduces the chance of feeling *information overload* for the users.

Keeping user's *presence awareness* up-to-date to the mobile application is another way to reduce the chance of *information overload* from the *Sources of Information*. By knowing user's presence information, mobile applications will be able to send information when users are available to receive. One way of doing it is to give users the option to choose the time period they are available to receive information. *Trafficker*'s "No disturb" setting realises this function and is welcomed by the users. However, it is also suggested by the users that the time period of choice can be more detailed. Instead of having only one time period of choice, the application should give several time periods of choice. In this way, users can divide

their available time into several periods, which is more common in reality.

Context-aware computing increases *Quality of Information* and helps to avoid *information overload*. By knowing user's context information, mobile applications will be able to send users the information they are most concerned about. It saves users the trouble of going through a lot of irrelevant information. *Trafficker*'s "Geo location" and "Transport type" settings both utilise *context-aware computing* to send users the information about their most concerned transport routes.

c) The third question is how to design the mobile applications to cater for travellers' needs.

The study shows that, a mobile application like *Trafficker* serves well the purpose of updating users with public transport information. Besides that, several design considerations are proved to be important for the users, therefore need to be taken into account when designing public transport mobile applications:

- **Privacy concern.** Mobile applications should protect user's private data from being misused. Users should also be given the freedom to choose which information they want the application to know.
- **Stability of the application.** Mobile applications should try to avoid crushing. Especially time is usually limited in travel situations, crushing may bring travellers more trouble than usual.
- **Simplicity of the design and function.** The design and function of the mobile application should be easy to use and easy to understand.
- **Readability of the information.** Conveying information is one of the main tasks for public transport mobile applications. The information should be short, clear, and easy to read, considering users may be walking or occupied by other tasks while using the mobile application.
- **Universal design.** Needs of different users vary a lot. Mobile application should be designed to try to satisfy as many travellers as possible. Based on travellers' different needs, designers may consider giving users more options for customizing the application.

8.2 Future work

This study chose one user from each of the four clusters to make the user group diverse. Due to the limit of time and scale, the study wasn't able to

study more users from each of the clusters. Therefore, it is not possible to make comparison among users from different clusters. In future studies, it would be interesting to include more users from each cluster and conduct statistics study, to see if there's a pattern in terms of contributing factors of *information overload*, and how they are increasing or decreasing *information overload*.

Moreover, the youngest user in this study is 26 years old. Mobile technologies have only started being a part of her life since her teenage year. It would also be interesting to conduct future studies on the generation who grow up with mobile technologies. They may have a total different views about obtaining information and the use of mobile technologies, compare to the elder generations.

Trafficker is proved by the users in this study to serve well the purpose of providing updated information about public transport, and reducing the chance of *information overload*. How the design really works in reality still needs more users' testings. *Trafficker* is so far a prototype due to the time limit of this thesis. It has the potential to turn into a functional mobile application in the future.

The results of this study are geographically and culturally bound to Oslo, Norway. The data may look different outside Scandinavia, or Western Europe in general. It would be a great further exploration and an assess of the generalisability of these findings if similar studies could be conducted under different culture settings.

List of Reference

Android Wear, 2015 [WWW Document]. URL http://www.android.com/wear/ (accessed 6.10.14).

Arhippainen, L., Tähti, M., 2003. Empirical Evaluation of User Experience in Two Adaptive Mobile Application Prototypes, in *Proceedings of the 2nd International Conference on Mobile and Ubiquitous Multimedia*, pp. 27–34.

Arnold, M., 2003. On the Phenomenology of Technology: The "Janus-faces" of Mobile Phones. *Information and Organization,* 13(4), pp. 231–256.

Bryman, A., 2008. Social Research Methods. Oxford University Press.

Butcher, H., 1995. Information Overload in Management and Business, in: *IEE Colloquium on Information Overload*. Presented at the IEE Colloquium on Information Overload, pp. 1–2.

Cao, J., 2015. 5 Psychology Secrets for Great Interaction Design [WWW Document]. URL http://thenextweb.com/dd/2015/09/03/5-psychology-secrets-for-great-interaction-design/ (accessed 9.3.15).

Card, S.K., Newell, A., Moran, T.P., 1983. The Psychology of Human-Computer Interaction. L. Erlbaum Associates Inc., Hillsdale, NJ, USA.

Carroll, J.M., 1997. Human-Computer Interaction: Psychology As a Science of Design. Int. J. Human-Computer Studies. 46, 501–522.

Chris Bank, Jerry Cao, n.d. Web UI Best Practices: UI Design from the Experts. Studio UXPin.

Creswell, J.W., 2009. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. SAGE Publications.

De Paula, D.F., Menezes, B.H., Araújo, C.C., 2014. Building a Quality Mobile Application: A User-Centered Study Focusing on Design Thinking, User Experience and Usability, in: *Design, User Experience, and Usability. User Experience Design for Diverse Interaction Platforms and Environments*. Springer, pp. 313–322.

Dix, A., Finlay, J.E., Abowd, G.D., Beale, R., 2003. Human-Computer Interaction, 3 Edition. Prentice Hall, Harlow, England; New York.

Eriksen, T.H., 2001. Tyranny of the Moment: Fast and Slow Time in the Information Age. Pluto Press, London, U.K.

Feil Stoppet Flytoget - Klar Tale, 2015 [WWW Document]. URL http://www.klartale.no/norge/togene-er-stoppet/ (accessed 3.11.15).

Finlay, M.F.-A., McMahon, D., 2015. Mobile App Push Notifications - The Next Frontier in Direct Marketing? [WWW Document]. URL http://www.lexology.com/library/detail.aspx?g=271fdffd-2879-4bf0-bfcf-a532d974b7ec (accessed 10.27.15).

Godefroid, P., Herbsleb, J.D., Jagadeesany, L.J., Li, D., 2000. Ensuring Privacy in Presence Awareness: An Automated Verification Approach, in: *Proceedings of the 2000 ACM Conference on Computer Supported Cooperative Work*. ACM, pp. 59–68.

Gold, R.L., 1958. Roles in Sociological Field Observations. *Social Forces*, 36(3), pp. 217–223.

Gross, B.M., 1964. The Managing of Organizations: The Administrative Struggle. Free Press of Glencoe.

Hemp, P., 2009. Death by Information Overload [WWW Document]. URL https://hbr.org/2009/09/death-by-information-overload/ar/1 (accessed 9.2.15).

Ho, J., Tang, R., 2001. Towards an Optimal Resolution to Information Overload: An Infomediary Approach, in: *Proceedings of the 2001 International ACM SIGGROUP Conference on Supporting Group Work*. ACM, pp. 91–96.

Holsti, O.R., 1969. Content Analysis for the Social Sciences and Humanities. Addison-Wesley Pub. Co.

Jackson, T.W., Farzaneh, P., 2012. Theory-based Model of Factors Affecting Information Overload. *International Journal of Information Management*, 32(6), pp. 523–532.

Jones, B.O., 1995. Sleepers, Wake!: Technology & the Future of Work. Oxford University Press.

Julsrud, T.E., Denstadli, J.M., Herstad, J., Hjalmarsson, A., Flyen, B., Li, Y., 2014. Mobile Applikasjoner Underveis - Hva Ønsker De Reisende?

Kjeldskov, J., Graham, C., 2003. A Review of Mobile HCI Research Methods, in: *Human-Computer Interaction with Mobile Devices and Services. Springer*, pp. 317–335.

Kjeldskov, J., Paay, J., 2012. A Longitudinal Review of Mobile HCI Research Methods, in: *Proceedings of the 14th International Conference on Human-Computer Interaction with Mobile Devices and Services*. ACM, pp. 69–78.

Lawson, S., 2012. Ten Ways Your Smartphone Knows Where You Are [WWW Document]. URL http://www.pcworld.com/article/253354/ten_ways_your_smartphone_knows_where_you_are.html (accessed 9.5.15).

Lazar, J., 2006. Web Usability: A User-centered Design Approach. Pearson Addison Wesley.

Lazar, J., Feng, J.H., Hochheiser, H., 2010. Research Methods in Human-Computer Interaction, 1 edition. Wiley, Chichester, West Sussex, U.K.

Lewis, J.R., 2006. Sample Sizes for Usability Tests: Mostly Math, Not Magic. *Interactions*,13(6), pp. 29–33.

Ling, R., 2014. From Ubicomp to Ubiex(pectations). *Telematics and Informatics*, 31(2), pp. 173–183.

Migrator, 2000. Advantages and Disadvantages of Mobile Technology [WWW Document]. URL https://www.nibusinessinfo.co.uk/content/advantages-and-disadvantages-mobile-technology (accessed 9.5.15).

Mobile Marketing Statistics 2015, 2015. [WWW Document]. URL http://www.smartinsights.com/mobile-marketing/mobile-marketing-analytics/mobile-marketing-statistics/ (accessed 9.5.15)

Mobile Phone Users Worldwide 2012-2018 | Statistic, 2015 [WWW Document]. URL http://www.statista.com/statistics/274774/forecast-of-mobile-phone-users-worldwide/ (accessed 9.5.15).

Nielsen, J., 1993. Usability Engineering, 1 Edition. Morgan Kaufmann.

Norman, D.A., 2002. The Design of Everyday Things, Reprint Edition. Basic Books, New York.

Randall, D., Rouncefield, M., n.d. Ethnography [WWW Document]. URL https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/ethnography (accessed 10.27.15).

Roto, V., 2013. User Experience – Why, What, How?

Rouse, M., n.d. What is Push Notification? - Definition from WhatIs.com [WWW Document]. URL http://searchmobilecomputing.techtarget.com/definition/push-notification (accessed 10.27.15).

Schlöglhofer, R., Sametinger, J., 2012. Secure and Usable Authentication on Mobile Devices. ACM, pp. 257.

Schmidt, A., 2014. Context-Aware Computing: Context-Awareness, Context-Aware User Interfaces, and Implicit Interaction. The Encyclopedia of Human-Computer Interaction, 2nd Edition.

Schmidt, A., Beigl, M., Gellersen, H.-W., 1999. There is More to Context Than Location. *Computers & Graphics*, 23(6), pp. 893–901.

Schusteritsch, R., Wei, C.Y., LaRosa, M., 2007. Towards the Perfect Infrastructure for Usability Testing on Mobile Devices, in: *CHI '07 Extended Abstracts on Human Factors in Computing Systems*,CHI EA '07. ACM, New York, NY, USA, pp. 1839–1844.

Shneiderman, B., 1997. Designing the User Interface: Strategies for Effective Human-Computer Interaction, 3rd ed. Addison-Wesley Longman Publishing Co., Inc., Boston, MA, USA.

Speier, C., Valacich, J.S., Vessey, I., 1999. The Influence of Task Interruption on Individual Decision Making: An Information Overload Perspective. *Decision Sciences*, 30(2), pp. 337–360.

Spira, J.B., 2011. Overload! How Too Much Information is Hazardous to Your Organization. John Wiley & Sons.

Strauss, A., Corbin, J.M., 1998. Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory. SAGE Publications.

Tehrani, K., Andrew, M., 2014. Wearable Technology and Wearable Devices: Everything You Need to Know. Wearable Devices.

The Association for Computing Machinery, n.d. Definition of HCI [WWW Document]. URL http://old.sigchi.org/cdg/cdg2.html#2_1 (accessed 10.14.15).

Toffler, A., 1984. Future Shock, Reissue Edition. Bantam.

Universal Design Principles, 1997 [WWW Document]. URL http://www.ncsu.edu/ncsu/design/cud/about_ud/udprinciples.htm

Weiser, M., 1991. The Computer for the 21st Century. *Scientific American*, 265(3), pp. 94–104.

Wellmon, C., 2012. Why Google isn't Making Us Stupid… or Smart. *The Hedgehog Review*, 14(1).

What is Presence?, n.d. [WWW Document]. URL https://support.office.com/en-in/article/What-is-presence-1f8dea49-

6d94-4930-a2e1-3df7704c2363 (accessed 9.4.15).

What is Universal Design?, n.d. [WWW Document]. URL http://www.universaldesign.com/about-universal-design.html (accessed 9.6.15).

Wiredu, G.O., 2007. User Appropriation of Mobile Technologies: Motives, Conditions and Design Properties. *Information and Organization*, 17(2), pp. 110–129.

Appendix A - Interview Notes

Interviewee A: Male 30

1. If I'm at work, I ask colleagues, or wikipedia on the tablet
   If I'm home, I use both tablet and computer.
   It depends on the type of the information. If it's work related information, I very often go to the books.
2. Yes.
   Work information, searched both internet and books, no answer.
   Other information, also have experienced trouble in finding information both on internet and books.
   The reasons are: wrong searching word, wrong places to search, difficult to find the right information from all the pop out unrelated information. A lot of information, hard to find the right one.
3. Like drawing best, writing is the most usual one. If search for some info and found out there're both drawing and writing, will go for the drawing.
4. Need to stand out. Not too long content. Not too long sentences. Easy to read. A lot of info. Clear.
5. Even if the writing is good, but if it's too long, still lose concentration. Most importantly is to make it short even the writing is not perfect, but good enough to get info.
   Fun or not, necessary or not, make a big difference.
6. Worse
7. prefer to be silent. Relaxed or not do not make much difference.
8. Sometimes too much info. Generally good, depends on the subjects. Sometimes too much, and also too much nonsense info, like ads.
9. Calling, message, facebook (look at interesting article, photo, video), checking time. I usually use it when I have spare time at work. I think it's a good way to waste time. By wasting time, I mean in a positive way because it's usually when I'm alone or I want to show my colleagues something on the phone.
   The bad thing about it is that it's addictive.
10. Yes. I don't have a solution for it.
    Depends on the type of info.
    Game invitation, pissed. If game or ads, 8-10 level annoying
    some others can be useful, I don't mind that much.
11. I like google maps. It gives me what I want.
    The pre-installed apps, most of them I don't need them. Among them, I'm only using google search, mailbox I see it's useful even though I'm not using. I don't have reason to try them because they don't seem useful to me. But they are asking for updating sometimes, some are connected, if you try to delete something, your phone has problem. I think there should be less pre-installed apps, you can choose to add the ones you need.
12. no. I don't use mobile much in those situation. When I have to, it's usually for example, the contact I usually use, so it's easy to find.
13. The change is good. I hate all the ads popping out all the time. It takes your time

from the real tasks. Ads is a negative thing on the mobile, it's not user-friendly. Pop-out ads is much worse than the one that shows at the bottom or the side of the page. The ads that break the page/article into several parts are also annoying.

14. .
15. It's good function. I see the value. But for me, it's not really a problem. My phone doesn't give much notification. But it may be useful for others.
16. Necessary, if use as a road GPS for example.
    Partly against it: if used by criminals, if they know for example everyone is out on vacation and the house is empty.
17. Some apps are gathering your search word. It's a good thing sometimes, provide convenience. But they are gathering a lot of info. I guess it's good for ads. But I don't need ads.
    Smart house is a good thing for people who need help like elder or disabled. Not necessary for a healthy person, would be nice to help to wash the dishes though. It's not a good thing to track too much of your biological info because they can be used by criminal for example calculating the chances you are not home. Those info can be used on the wrong hand.
18. Mobile phone, tablet, desktop, x-box.
19. Enough
20. work-related situation, yes, but not really a pressure. If it's close family want to reach me then it's must be something important. Friends, I only reply when I feel for it. So not a problem.
21. At work. The wearable devices to detect the pressure, oxygen, etc, tell you if you need to leave the room, also gives alarm when you are stressed or have a shock in a small space.
22. It's necessary. No extra burden. Easy to use. Small.
23. no. unpractical. Stuck on your arm, small screen, not easy to read.
24. 3 times a month.
25. Either on desk top, or I just go to the station and check on screen there. Yes, easy to find on the desk-top.
26. Yes. Not that often it happens. Then I just wait a bit more. Use it bit more time. Not really much bother. And when I use public transport, it's usually not emergent situation. I drive to work. 2 level bothering.
27. No
28. No
29. yes
30. read them. 15-20%
31. I'm aware of it. I read a bit, if interesting/valuable, read more. Depends on the news.
32. Yes
33. No. If I don't feel like it, I just stop reading. If news is boring, I only read the ticker. It's not affecting me if I choose not to read.
34. Ticker, I like the concept.
    It can be useful also for other traffic, for example, car driving. You can tell if there's road maintenance, queueing, jam, which patrol station is the cheapest. It'd be nice to combine the function of ruter reise, nsb and other apps, such as weather and temperature info. I want an app to cover the general info concerning travel.
    Ticker itself, gives me enough info, clear.

Setting: clear message about the options.
No disturb: useful, nice to have it there. Since the notification doesn't bother me much, it's not necessary for me. Would be nice to set several time period.
Geo: if the GPS can be off at certain time it would be good. Nice. Narrowing downing info, will use it.
Type: good enough.

35. Yes
36. .
37. Orange on the setting page is not outstanding enough. For general population it's good enough but may be not for people with bad eye sight.
    Info page: giving more info, but not too much more, short and clear, user shouldn't spend too much time on reading it.
    Colour should make it more outstanding especially if you are reading while walking.
    Ticker: nice, small. But the bus number may be a bit bigger to be more clear.

Interviewee B: female, 26

1. google, on mobile (most often), sometimes laptop.
   Not any more to books.
2. Always find the one I need.
   Depends on the topic, if popular, easy to find, if personal wonder, not so much info.
   Not have trouble searching things.
3. Read, on books/phone. I like reading
   sometimes videos are easier, for example, youtube
4. Yes. If too much texts, I don't concentrate, fall out easily.
   If it's fact info, it's easier if it's short with pictures.
   Don't like A4 page with only texts, too much info.
5. Well written, is easy to understand the meaning because the words are put in the right way.
   If it's fun, better, because I tend to fall out easily.
6. Read worse, stressed.
   When there's time pressure, I try to concentrate, try to read, but not understand. Time pressure affect my concentration.
7. No difference. I'm easily got into my own bubble if it's interesting. If it's not interesting, then I will not read. If I have to read, then as long as I'm alone, I can read easily.
8. Can be too much info sometimes (10%)
   for example, last summer, the terror attack threat, too much info.
   Depends on the situation, if I need it or not.
   Sometimes too much/little/not too much
   depends on self-choice if continue reading or not.
   But sometimes, i'm curious, I can't stop even feel it's too much info all ready. I feel like I have to, even I feel no I don't need it, but I still continue.
9. Facebook, one game, message (more than calls), google, e-mail, taking pictures, social media (instagram, ...) bank info.
10. Yes. 6-7 level disturbed
    when I'm doing something, if it pops up, I feel like I'm looking at it all the time. I

try to ignore it, or sometimes check it, then put the phone down.
I know I can turn off the notification, I don't know why I didn't.

11. Yes. The pre-installed apps, some are unnecessary, such as the stock one, I can't delete, I don't need them. I should have free choice to download them or not. Pre-installed takes space, updating them is not a trouble for me, but it's just irritating.
12. Not easy all the time. Walking is most difficult. So usually I try not to. 40% of my walking time I'm using the phone. I feel it's annoying when other people do it, so they don't see the road, etc.
13. Both positive and negative.
    Negative: It takes a lot of your time. I find myself not following other people's speaking, then I have to ask again. You lose contact with the real environment around you.
    Positive: you can keep track of a lot of things. Find out things. I think it's more FUN than POSITIVE to be accurate.
    Generally it's more negative.
14. (Checking her phone during the interview, discovered the function of turning on or off each app's notification individually, explore more of the “don't disturb” mode on iphone. If the function is easier for user to understand to find out the function, they wouldn't miss out it if they are very advanced user of mobile tech. They can't go through all the info.)
    I'm using “don't disturb” when sleeping, but it only turns off the sound. (while checking her phone, she discovered more options in this mode, you can choose to allow some important phone call to have sound for example)
15. useful for me! Like the old phones. Now the phone has too little choice.
16. I think all apps have it. I don't think about it. When I use the map, it's really useful. Because I usually don't know where I'm. For facebook messenger for example, you can turn it off. Many apps want to know your location, you feel you phone knows everything. But you can turn it off or on for each app.
    Not negative, cos I know I can choose.
17. It's fun
    I see how tech affect people, people use tools instead of doing things themselves. If choose between regular and smart house, I would want regular. I don't want tech to take over my life, it scares me.
    For example, when people use wheels for steps, people just got fat.
    I'm ok with phone and pc, but not smart house. May be good for old/disabled people, but should not be for young, body functioned people like me.
    Things can go a bit slower.
18. Running watch/polar watch. Nintendo Wii, app tv, 3 phones, ipad, mac book, regular laptop, 5 laptops, 2 ipod, tablet.
    Usual use: iphone, aser pc, watch, ipad sometimes.
19. Yes. A new macbook, even though I have a good laptop.
    I like mac, easy to use, and I got used to it from before when I was studying graphical design. It's easy for photographic programmes. Iphone can link to it.
20. Not so often. Usually have the sound off. I don't miss things because I can keep the vibration on, and I check my phone very often.
21. Polar watch.
22. I love it. When out running, I put on the belt on the chest, so it shows pulse, activity level.. I like wearing it. I like tracking. It kinda becomes a obsess. I don't

take it off almost all the time.

23. I will have both. I will not only have watch because it's not easy to see the operate on the small screen all the time.
    I'm interested in apple watch. Although I think my watch now is satisfying my need very well. I don't need to have all the apps on the watch, when I have them on the phone.
24. Everyday.
25. Apps on the phone. Ruter reise, nsb, ruter billett, norwegian flight.
    Easy to find the info I want.
    Although ruter sometimes not updating fast enough, shows wrong info, has caused me trouble.
    Ruter also crashes sometimes, often enough.
26. Sometimes the train leaves 1/2 minutes earlier than the app, it's frustrating.
    It has happened sudden delay, not knowing before hand. If the app can have the favourite train, and gives info, it'd be smart. Nobody has the time to check every time before leaving in the morning.
27. ..
28. add the function of choosing favourite bus for example, will be easy for people. Most thing I dislike is crashing.
29. Yes.
30. Try to read everything. Got a lot info from it. Twits, news and so on. I notice them. They are not annoying while watching the news. It has 50% of my attention. If I see something interesting, I will google it.
31. A lot of info.
32. Yes.
33. Not tired. Up to yourself if read or not. You can pay attention to both. Not disturbing for sure.
34. Ticker. Like it. Easy to follow when something happen. Useful, easy to read. Won't be in the way all the time, so less disturbing than regular notification.
    No disturb: useful, smart.
    Geo: useful
    type: useful. Will use all three functions.
35. Easy to understand, can narrow down to the info you want, easy and useful, you got the info you want.
36. .
37. info page, easy to read, grey and white is ok, colour will be disturbing.
    Size matters if it's readable.
    Length is ok even if it's long.
    Font matters, don't like curry and cute style, more difficult to read, you got disturbed.

Interviewee C: female, 63

1. Before, book, or Encyclopedia (leksir) (text+photo), ordered with letter, easy to find info, need to buy new ones after a while because new knowledge will be added over the years. Need to update.
   Now, google on laptop. Not use book much any more.
   But I like reading books.
   If map, I like both map on the book and google map.

Map on the book, you can get the whole world on a big map (can put it on the wall), you can see better, better view, you can explain to people, point out to the area you are from, interaction with people, and I like paper.
Google map is nice in the way you can see details better, one road, or check the route, and see photo of the street and area.
If check photo number, I like internet much better than the old yellow page on book.
(only info, format doesn't matter, if there's the possibility or the need for interaction, then like the paper format)

2. yes. If you know what you want to search, you can. If you are not certain about the info you are searching for, it takes a bit time to find which search word is the best.
   Before, more difficult, has to go to books or people, or somewhere.
3. Read, photo, video, listen, some situation smell (food). Depends on the situation
4. easier to read if well-organised.
   Catch your attention better if big letters.
   Depends on the type of article: if novels, doesn't matter that much, if newspapers, I like different size words, easier to pick up the article I want to read. If textbook, some have extra info on the side to explain, it's good.
   If I read a lot, I read better, faster, not word by word.
5. Yes. If I like the article, I read better. Boring or not important, worse.
6. Not easily stressed usually. But special situation, may not easy to concentrate. If exam, I'm calm, a little excited helps, I do better.
7. Not that much, but can be a bit distracting.
   T-bane better, more stable than bus.
   I read everyday, t-bane, bus
8. very much info compares to before, from the whole world, you only need to sit in the living room.
   Tv news, when there are a lot of sad things, you find yourself trying to defend yourself from all the info.
   Sometimes it's nice to have less. Info society, we have a lot of info. Maybe many will have problems with reading. You watch a lot Tv, but you still need to read a lot, bills...info society can be problem for old people who can't use pc.
   If it's important for me or I need to, I will try to learn new technology, new software...but you need to get to know all sorts of info/how to use them to be better living in info society, therefore, for some people, it's a problem.
   Before, when I'm abroad for one year in 1970. I wrote a lot of letters. Now it's big difference. I like now, much more choices. When I'm driving alone especially when it's winter, slippery road, having the mobile make me feel safe, and I find things fast.
   Generally, maybe enough. I feel I can find everything. I cut myself out when there're too much info. For example, ads on the wall in the station. But sometimes even you don't want to see, suddenly it pops into your eyes.
9. Message, call, take photo, google (very little), read newspapers (on the way to job, in the morning, not often), e-mail, bank.
10. Yes. At work, no sound.
    Sometimes disturbing, for example, when other people are sleeping, it rings, it's a problem.

If visit doctor, theatre, I turn the sound off.

11. Newspapers&email (see the number of unread emails)
    I only use newspaper, email, alarm, message, call. Apps
12. not so much trouble. Only call or message.
13. Positive.
14. If I remember to adjust the sound, it's not much problem. I can see it can be useful for some, it may also/can be useful for me, hmmm, but I don't learn new tech that fast.
15. .
16. not so much problem for me. For some, maybe a problem.
17. If you are disabled, maybe.
    Now I don't think I need. It's good to know a bit about using pc, though, before getting old.
    I heard on the news that an old lady who lives alone have a big tablet on the wall, where she can call, video chat...it's very good and convenient for her.
18. Mobile, laptop.
19. Yes
20. I don't check email everyday. I like best messages and calls. I don't need to read message and call immediately, but once everyday at least.
21. ..
22. ..
23. too small to read. Maybe useful for me, but not now.
24. 5 days a week.
25. Read the time table at the station. If long-distance bus, or not my routine trip, I check google first.
26. Sometimes, not so much.
    Sometimes, one didn't come, I need to wait for 15 minutes more.
    When there's snow, more problem.
    Not so much problem with bus and t-bane (I usually take).
    Train more problem (my colleagues take them or I hear from radio, or info from the loudspeaker, or showing on the digital screen)
    t-bane, I don't need to know the time, it comes every 7 minutes. At work, there's a screen showing traffic info.
    Change happen not so often, not really a problem.
27. ..
28. maybe it's useful to but the monthly ticket
29. yes
30. 10-20%
31. yes, if important
    like tv 2, showing program list with time.
    If there's interesting info for me, I look.
32. Yes. It doesn't fit to all program though.
    If I'm watching entertaining program/film, I feel I'm free, I don't want more info all the time. I like news everyday, but not all the time.
33. Not. I have never thought about it, I see a bit, but not read much, if there's anything special, I follow.
34. Ticker: For me, not that useful, not that much happen to my route. But maybe useful for those who has more changes.

No disturb: can be useful for people, even for the line that doesn't change much. It doesn't distract me so I consider, it's possible for me to use. But you know, it takes time for me to use a new app.
Geo: useful.
Type: useful. But if I need to take some route suddenly, or pick up somebody, do I need to add?

35. If the texts is too small, not so easy without glasses which is not that useful on the road, it would be nice to have the function where people can change the font size themselves according to the needs.
36. The ticker info need to be short. Good. Then people can choose if they want to read more, then it's ok to be a bit long texts.

Interviewee D: male, 27

1. google, wikipedia, usually/try to use laptop, if there's no laptop by the side, use mobile, very often have laptop with me, when travel, use mobile.
   Almost not use book at all.
2. Most cases, I can find. If I know very little about the thing I'm searching for, don't know where to start, then it's difficult. If it's work related (research), few people have been on the topic, then it may take me half year.
   Filtering the info, I will check out many, and see which one makes more sense; if it's the topic somebody talked about before, then I will have a previous impression, then I may tend to believe what I heard before.
   Tired or not, it depends on my status, if I'm already very tired, I will feel more tired, if I have time and energy, then no effect.
3. If it's something serious, then I prefer words, it's more rigorous
   if it's something relaxing, then video
4. may affect my concentration. If I have time, then no effect, if no time, then effect.
   If the words are very small, no interest. On pc and mobile I usually make the size bigger.
5. The way the words are presented affect my understanding.
   If interesting, or I like, I understand better.
6. Worse. I will read through very fast, but may not really understand.
7. Yes. If i'm sitting int he bus, I wouldn't read well, my concentration is low.
   Also depends on the mood, if I have a good mood, I read well.
   If I'm on the long distance flight, I'm anxious to land, and people around, it's hard for me to concentrate
8. compares to before, enough.
   But never enough.
   There are so much info nowadays, we need technique to analyse.
   Sometimes I feel there're too much info, usually it's when time is tight and I have to make a decision. If I have time, I don't feel it.
9. Read news (most often), listen to the news, a bit social network, google if I don't have pc with me, navigation (walking), email, translation, weather, travel.
10. I turn the notification sound off. May be have the ones that I'm most concerned sound on.
    Normally don't feel disturbed, because I can control the notification.
    When I'm working, I don't have much phone, social network at all (I also turn the notification off, only if I know I'm waiting for important message to come, I will

turn it on)

11. podcast (iphone app) I can listen to many broadcast, BBC, NRK.
    Video app, check interesting videos, relaxing.
    News app, good, provide info. If I don't have much time, I don't look at news, even if sometimes when I saw the title I feel like reading more, but I don't have time, then I will just forget about it.
12. Waiting for the bus, ok, kill the time.
    I usually check beforehand.
    I don't like type on the phone, usually use pc. If I have to reply on my phone to message or email, it will be only very short reply.
13. Positive. No negative moment
14. no
15. too complicated, different modes.
    If I need it on, I will turn it on manually. Or off.
    Also my time is not stable, I may want it on today for a while but not for tomorrow. Sometimes I want to see it at work, sometimes not.
16. Convenient when taking photos
    a bit worried other people may make use of it, but at the same time thinking I'm just a normal person, not in big danger of being followed.
    Still little worried people will use the info to do things against me. So I usually turn off the geo for apps, I usually don't believe small app companies. I trust much better the big well-known ones.
17. If many people have tested and say good, then I will believe it more.
    New technology, the stability and many issues are concern.
    Privacy is a concern for smart house. Maybe I will consider when I'm old, when privacy is not as important as my health.
18. Laptop, desktop at work, mobile, tablet.
19. Enough (sensibly thinking)
    Sometimes want a mac book, only because it's light and easy to carry.
20. Most occasion not. I usually check once a day, that's enough. I usually don't have much emergent thing.
21. .
22. .
23. don't need. Don't trust wearable.
    I usually don't trust new technology only until many people are using.
24. Everyday
25. I don't check time, many t-bane. When I'm off the work, I will walk to the station where there're more lines even though it's longer walk, so I don't have the trouble to check the time.
    When I was living in kringsjå student village where there's only one t-bane line. I will check before hand on the pc, to decide when to leave.
    Ruter reise is good.
26. Quite often. Usually delay.
    When living in kringsjå, big effect, especially winter, cold. But I can't avoid it for next time because I don't check the time every time.
27. ..
28. no. I don't use them often.
29. If people remind me, I will check. Normally I only look at the news.

Some ticker has ads, don't like them.

30. 10% at most.
31. I don't feel like getting a lot of useful info. If important, it should be shown on the big screen instead of ticker.
32. Not much use.
33. If it's rolling, it's tiring to read. It pasted already before I understood. I don't like this way.
34. Ticker: useful. I'm getting when I need. I can choose what I need and want. It will take some of my attention since it's on the home screen. My iphone screen is small, I hope it won't take too much of my screen space. I don't like rolling.
    No disturb: may use, during some certain period
    Geo: useful
    type: very useful
    The functions are good enough and contain enough info.
35. Long or short, have effect, if the text is long, I prefer to have a short abstract in the front.
    Colour, as long as it's clear to see.
    Fonts, as long as it's normal, don't like the cute, wired types.

Appendix B - Guides of Interview and Usability Test

Guide A – Interview Guide

Information overload:

1. In the old days, we usually turn to books, magazines, newspapers or other people when we need information. How's the situation now for you? For example, when you have a question: what's the population in China.
2. Have you experienced the situation of going through a lot of information without being able to find the one you want?
3. Do you prefer some certain format of information better than the others? For example, writing, drawing, sound, smell, feel.
4. In terms of writing information, do you think the way the words are organised affect your reading? For example, books, magazines, newspapers.
5. Do you find it's hard for you to obtain information if the article is badly written? Do you read better if the article is fun instead of boring?
6. Give you a certain time, for example when you are in the class, you need to read something within a certain time and get the meaning, in that case, do you read better or worse?
7. Reading newspaper for example, do you read better in some certain environment? For example, when you are sitting at home with coffee, relaxed; or when you are sitting on the bus.
8. In the information century, do you feel like you are getting enough information, not enough, too much?

Use of mobile phone:

9. What do you usually use your mobile phone for? What's the most frequent activity?
10. Do you sometimes feel disturbed by the notification from mobile applications? If so, how do you deal with it?
11. Do you like some application better than the others? What are the reasons for the preference?
12. Is it sometimes a trouble to operate on the mobile phone while you are waiting for the bus, walking on the street, etc?
13. Do you have a general positive, neutral or negative feeling towards the changes mobile phone brings to your life? What's the positive thing about it, what's

the negative thing about it?

Presence awareness:

14. Some app's function of adjusting availability of receiving notification.
15. If there's a choice of turning your phone into different mode: home mode, work mode, travel mode, and sync with different application, how do you like it?

Context awareness:

16. Mobile knowing your location.
    Like it? Convenient? Any trouble? Any concern?
17. Would you choose to live in a smart house?

Ubiquitous computing

18. Can you count all the computing devices you have?
19. Do you think it's enough? If not, what more do you need?
20. Do you feel the pressure of keeping the phone on, keep the sound on? Any other pressure from the phone?

Wearable technology:

21. What wearable do you have?
22. How do you like it?
23. Will you consider having a smart watch instead of mobile phone in the future?

Use of public transport:

24. How often do you use public transport?
25. How do you usually get information about real-time public transport? Is it easy to find them?
26. Have you experienced sudden change in public transport? If so, how did it affect you? Do you have a solution for it?
27. Are you using any public transport mobile application? If so, what are they? How do you like them?
28. Any possible improvement you would like to see?

Guide B - Usability Test Guide

Ticker design:

29. Do you notice the ticker on the bottom of the TV news?
30. How much attention do you pay to the ticker?
31. How much information do you usually get from the ticker?
32. Do you consider it useful?
33. Do you feel tired of reading the ticker while watching the news?

Trafficker:

34. Each function, do you think it's useful?
35. Do you think it's easy to use?
36. Will you consider download it if it's available?
37. Does the size, colour, font, length affect your ability of reading the information?